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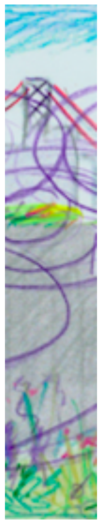

Methodical and design concept for the development of natural green roofs with a Narrative Environment - Applied to the case studies Meret Oppenheim High-rise in Basel and a Residential Building in San Francisco.

Bachelor Thesis

from

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Abstract

Natural green roofs are a proven instrument in urban ecology. They can bring biodiversity into urban areas and commit to sustainable architecture. As a standard, many research methodologies on creating biodiverse green roof concepts emphasize the site-analysis of the structural and ecological functional aspects. The esthetical and socio-cultural context is often left aside. This, however, can lead to little acceptance by the visitors because the 'natural look' of a green roof does not aesthetically appeal at all times. Therefore, the green roof gardens cannot be fully enjoyed and understood within all of their functions. The following questions arise: How can the acceptance of nature be awakened and how can nature on the roof be installed so that people can connect to it? How can function and aesthetics be merged and put into green roof concepts and planning?

Narrative Environments are communicative environments created in space, which enable experienceable learning. Settings are devised to enable a new understanding and view of nature and culture. Therefore, in this Bachelor thesis, the author suggests that Narrative Environments can be a way to bring together cultural aspects with nature on green roofs. By use of natural elements and structures, nature is landscaped in an esthetical way in order to appeal to many senses. Hence, this designed nature can be experienced in a more complete way, through the incorporation of a Narrative Environment concept. The result can be that audiences feels excited and can better embrace nature. This might lead to a higher acceptance of biodiverse green roofs and increased installations.

The main research question in this thesis is:
How can incorporating a Narrative Environment into the design of biodiverse green roofs as a method provide guidelines for the design of biodiverse green roofs in a socio-cultural context?

In light of this perspective, this paper develops a method called CoNaNalysis. Its name stands for **CO**ncept, **NA**ture and **NA**rrative-Environment ana**LYSIS.** It combines site examination in its functional and ecological aspects along with the techniques of a Narrative Environment.

Based on the recognized knowledge of the effect of a Narrative Environment on ground space, the author hypothesizes that this method can be an innovative way to design aesthetically appealing biodiverse green roofs that can be highly accepted by visitors. As a guideline, CoNaNalysis can be applied to create green roofs in a socio-cultural context.

This method is experimentally tested, applied, and discussed in this paper through two case studies. The first case study is the Meret Oppenheim Building roofs in Basel; the second is a rooftop on a residential building in San Francisco.

The results demonstrate that the combination of a tailored site analysis with the methods of Narrative Environment in CoNaNalysis can be successfully applied in both case studies. The method enabled to identify natural elements and native plants that can be integrated in the design of a Narrative Environment on green roofs that promotes biodiversity. Yet, due to the inherent limitation of having only two case studies, these results cannot be generalized. Further case studies will be needed to analyze more deeply the potentials of the method and its broader effectiveness. The author hopes that CoNaNalysis can make a substantial contribution to create more biodiverse green space in densely built cities and promote biodiversity in urban areas. She encourages landscape architects and planners to implement this method for the design of green roofs. Finally, scientific evaluation on its effects can help to further refine the method and extend it to other types of green roofs.

Zusammenfassung

Naturnahe Gründächer sind ein bewährtes Instrument in der Stadtökologie, da sie zu einer erhöhten Biodiversität in städtischen Gebieten beitragen können und der nachhaltigen Architektur gerecht werden. Zur Entwicklung von artenreichen Gründachkonzepten wird häufig eine Standortanalyse bezüglich der strukturellen und ökologischen Aspekte durchgeführt. Der ästhetische und soziokulturelle Kontext wird dabei oft vernachlässigt. Dies kann jedoch eine geringe Akzeptanz bei den Besuchern zur Folge haben, da das "natürliche Aussehen" eines Gründachs mit extensiver Bepflanzung ästhetisch nicht immer ansprechend ist. Da nicht all ihre Funktionen verstanden werden, können diese Dachgärten nicht in vollem Umfang genossen werden. Daraus ergeben sich folgende Fragen: Wie kann die Akzeptanz der Natur gefördert werden und wie muss die Natur auf Gründächern realisiert werden, dass sich Menschen darin wohlfühlen? Wie können Funktion und Ästhetik zusammengeführt und in Konzepte und Planungen von Gründächern umgesetzt werden?

Narrative Environments sind erzählende Umgebungen, die auf erzählerische, spielerische und aktive Weise das Lernen ermöglichen. Ein zentrales Element dabei ist eine gestaltete Umwelt, die ein neues Verständnis und eine neue Sicht auf Natur und Kultur ermöglicht. Diese Bachelorarbeit stellt Narrative Environments als eine Möglichkeit vor, kulturelle Aspekte mit der Natur auf Gründächern in Einklang zu bringen und diese durch den Einsatz natürlicher Elemente und Strukturen ästhetisch zu gestalten. Dies könnte zu einer höheren Akzeptanz und vermehrtem Einsatz von naturnahen Gründächern führen.

Die Hauptforschungsfrage dieser Bachelorarbeit lautet:
Wie kann der Einbezug einer erzählenden Umgebung (engl. Narrative Environment) in die Planung von artenreichen Gründächern Richtlinien für die Gestaltung von artenreichen Gründächern in einem soziokulturellen Kontext liefern?

Die vorhandene Literatur betreffend die Wirkung von Narrative Environment lässt vermuten, dass sich damit auch ästhetisch ansprechende, biodiverse Gründächer entwerfen lassen, die akzeptiert werden. In diesem Sinne entwickelt diese Arbeit die CoNaNalysis-Methode, welche die Standortanalyse bezüglich der funktionalen und ökologischen Aspekte mit den Techniken des Narrative Environments verbindet. CoNaNalyisis steht für **CO**ncept, **NA**ture und **NA**rrative-Environment ana**LYSIS**.

Die CoNaNalysis-Methode wird im Rahmen der vorliegenden Arbeit in zwei Fallstudien experimentell getestet, angewendet und diskutiert. Die erste Fallstudie sind die Dächer des Meret Oppenheim Hochhaus in Basel. Die zweite Fallstudie ist ein Dach auf einem Wohnhaus in San Francisco.

Die Ergebnisse zeigen, dass in beiden Fallstudien die Kombination einer Standortanalyse mit den Methoden der Narrative Environment mittels der CoNaNalysis-Methode erfolgreich angewendet werden kann. Die Methode ermöglicht die Identifizierung von natürlichen Strukturen und einheimischen Pflanzen, die in die Gestaltung einer narrativen Umwelt auf biodiversitätsfördernden Gründächern integriert werden können. Aufgrund der Anwendung der CoNaNalysis-Methode in lediglich zwei Fallstudien können diese Ergebnisse jedoch nicht verallgemeinert werden. Um die Potenziale der Methode und ihre breitere Wirksamkeit tiefer zu analysieren, sind weitere Fallstudien nötig. Die Autorin hofft, dass CoNaNalysis einen substanziellen Beitrag zur Erhöhung der Biodiversität in dicht bebauten Städten und städtischen Gebieten liefern kann. Sie ermutigt Landschaftsarchitekten und Planer, diese Methode bei der Gestaltung von Gründächern anzuwenden.

Contents

1 Introduction

1.1 Starting position

1.1.1 Urban areas and biodiversity

The worldwide population is increasing rapidly. Nowadays, 55% of the world population lives in urban areas. It is to be expected that in 2050 it will increase to 68% (United Nations, 2018). At the same time, the quality and quantity of natural biodiverse habitats are disappearing due to altered land-use (Tuiller, August 2007), human-caused fragmentation (Opdam & Wascher, 2004), and intensified traditional agricultural practices (McLaughlin & Mineau, 1995). However, cities and urban areas offer many niches where flora and fauna can find retreat and substitute-habitat. Moreover, due to its structural heterogeneity, biodiversity in cities is often higher than in its surrounded area, which makes cities potential hotspots for biodiversity (Lepczyk et al., 2017).

Often, in urban areas, the habitats are characterized as small and diversely structured. Cities offer or a patchwork of habitats and replacement habitats (habitat islands). However, increased densification in cities only leaves little room for green space on the ground level. Green roofs can mitigate this loss.

1.1.2 Green roofs and biodiversity

Green roofs fulfil many functions and their manifold benefits and ecosystem services are well investigated (Oberndorfer et al., 2007). They are nowadays recognized as part of sustainable and ecological urban infrastructure. Many recent studies in this field concentrate on the more specific aspects of the potential of green roofs as habitat for biodiversity (Brenneisen, 2006; Oberndorfer et al., 2007; Tonietto et al., 2011). As part of the urban green infrastructure, green roofs are an effective instrument to provide structural diversity, extended habitat for flora and wildlife and can help conserve habitats and species (Köhler (1993); Brenneisen (2003); Madre et al., (2013); Catalano & Baumann, (2017).

Brenneisen (2003, 2006); Kadas (2006); Pétremand et al., (2018) provide evidence that green roofs can offer habitat to many invertebrates in urban areas. Green roofs can fulfill the function of stepping stones and - if large enough – offer permanent habitats for many mobile species living in urban areas (Brenneisen, 2006).
Braaker et al., (2014) investigated on arthropod communities on 40 extensive green roofs and 40 green sites in Zurich and pointed out the high importance of habitat connectivity in creating high-mobility species community compositions. It suggests that connectivity can increase urban arthropod biodiversity, also for

low-mobility arthropod species. Not only invertebrates find habitat on green roofs; Pearce & Walters (2012) proposes that green roofs can offer habitat for bats in urbanized areas in the United Kingdom for example; Also the ground-nesting bird *Vanellus vanellus*, (northern lapwing) forages and nests on some extensive green roofs in Roth, Switzerland (Baumann N. , 2006). Brenneisen, (2003); Catalano et al., (2016); Grant, (2006); Kyrö et al., (2018); Pétremand et al., (2018) and Williams et al., (2014) show that nature conservation and creating habitat for endangered species, both flora and fauna, on green roofs play an essential role in the preservation of biodiversity in cities. Brenneisen, (2006); Catalano & Baumann, (2017); Dunnett et al., (2011) and Pétremand et al., (2018) provide guidelines and design criteria on how to create biodiverse green roofs for a specific climate zone. These can be used for the installation of new green roofs but also to improve the ecological quality of existing extensive green roofs.

1.1.3 Bringing Narrative Environment into the design of biodiverse green roofs

While often the focus of green roof research and guidelines concentrate on the ecological and functional design of nature, the esthetical design and the effect on its audience is paid little attention to. Sutton (2014) recognized the importance of the suggested ways to make easthetics more relevant and understandable to the practice of green infrastructure (green roofs and green walls). He invites green roofs designers to engage the user in the design process to improve interaction with the environment

> “ultimately improving our sense of connectedness.” (Sutton, 2014, p. 10).

He recommends designing green roofs as an eye-catcher to diminish the depreciation of unexciting extensive green roofs. Yet, a systematic approach (method) to create attractive biodiverse green roof concepts where the audience can be involved is missing.

An instrument that enables to experience nature and connects to ecological topics is a Narrative Environment (Baettig-Frey & Jaeger, 2018) it is a communicative and storytelling environment, taking place in any type of situation with the goal to convey any content or idea (Mueller, 2011). As a recognized instrument in the context of sustainability, a Narrative Environment tells a story that appeals to many senses. That way, it offers room space for identification with nature and experienceable long-term learning (Baettig-Frey & Jaeger, 2018).

Figure 1 to Figure 4 present three examples of green roofs where Narrative Environments became part of the concept: Meadow Carpet the green roofs of the Main Exhibition Hall 1 (Messehalle 1) in Basel and the

Monument Building in London (Jaeger, 2017; Dakin et al., 2013). These cases show green roofs design that support biodiversity and offer an interesting aesthetical experience to the audience.

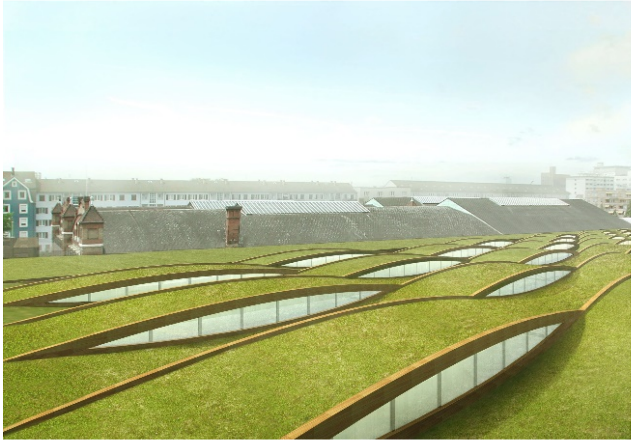


Figure 1: Project "Meadow carpet". Architects Baader Architects, Basel. Image: S. Brenneisen

Figure 2: Project "Meadow carpet" Architects: Baader Architects, Basel. Image: S. Brenneisen

Figure 3: Biodiverse green roof Main Exhibition Hall 1 in Basel. Image: greenroof.com

Figure 4: Green Roof of the Monument Building in London. Image: www.e-architect.co.uk

1.2 Goal and contribution of the Bachelor Thesis

Specific examples of green roofs demonstrate that such areas on buildings can be considered from the perspective of Narrative Environment and that this method could play a role in the planning and designing of green roofs. The aim of the present Bachelor thesis is to pursue this approach. Methods in various study areas are to be tested so that exemplary solutions can be developed.

This paper aims to incorporate Narrative Environments into the concepts of biodiverse green roofs (see task description in Annexes). The goal here is twofold: to integrate Narrative Environment into the design of green roofs so that visitors will feel more connected to them, and for the visitors' senses to be stimulated and pulled into the natural setting. This might help to invoke a deeper comprehension of the value of a biodiverse green roof. The added value of a more engaging human experience with green roofs might increase their acceptance and encourage landscape architects and green roof designers to promote their installation.

1.3 Research question and hypothesis

The research question is: ***How can incorporating a Narrative Environment into the design of biodiverse green roofs as a method provide guidelines for the design of biodiverse green roofs in a socio-cultural context?***

The author of this paper investigates methods formulating concepts for green roofs that combine ecology and art, and therefore connects urban ecology benefits with the idea of a Narrative Environment. The aesthetical aspects help to experience urban nature more pleasantly. Materialisation of the Narrative Environment promotes biodiversity.

The design goals are formulated as follows:

- Create a biodiverse self-sustaining green roof
- Apply a Narrative Environment to make it aesthetically appealing or provide educational value

Based on the recognized knowledge of the effect of a Narrative Environment on ground space, the author hypothesizes that:

Hypothesis 1: Green roofs offer suitable space for a Narrative Environment.
Hypothesis 2: In each region and climatological zone native plants and native plant communities can be found to create a biodiverse green roof with different plant communities.
Hypothesis 3: In each region and climatological zone natural materials can be found for the design of the roof structure and microhabitats.
Hypothesis 4: This creative combination is a novel way to design aesthetically appealing biodiverse green roofs that can be highly accepted by visitors. As a guideline, it can be applied to create green roof concepts in a socio-cultural context.

1.4 Procedure

The author looked at different recognized site analysis methods used in green roof construction, landscape design, and ecological planning, and evaluated them to create a site analysis guideline that suits in the context of this paper.

To support and test this new method, two different base concepts for natural green roofs with Narrative Environment were created, both in different cultural and climatological environments. The first case study is the high-rise Meret Oppenheim in Basel, with Oceanic climate, for commercial and residential use. The second case study is a building in San Francisco, with Mediterranean climate, for residential use.

In the third and fourth sections of this paper, the method and concepts are presented and evaluated methodically. The results and their impact on the field of green roof design and planning are discussed. Costs and implementation (realization) are beyond the scope of this paper. A possible option to include solar panels and rainwater collecting systems should be considered in future studies.

2 Theory

2.1 Biodiversity

> «*Biodiversity is defined as the variability among living organisms from all sources including, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems*». (UNEP, 2018).

Biodiversity stands for the diversity of life. It includes a variety of living spaces (habitat), from species and genetic diversity. Therefore, it builds the base for all existence on this planet, our life, our health and our wellbeing (Secretariat of the Convention on Biological Diversity, 2014). However, biodiversity is in danger. According to the latest update (Version 2018-01) of the International Union for Conservation of Nature's (IUCN) "Red List of Threatened Species", globally more than 26'000 species are threatened with extinction. This is more than 27% of all studied plant and animal species (IUCN. International Union for Conservation of Nature and Natural Resources, 2018).

Each species fulfils many different functions within the ecosystem. They play a role in many ecosystem services such as pollination by insects and pest control by predator species (Secretariat of the Convention on Biological Diversity, 2014). Therefore, the loss of biodiversity presents a risk for the future of life on our planet. The main causes for loss of biodiversity are identified as habitat fragmentation and climate change (Opdam & Wascher, 2004).

California

Due to its complex landscapes concerning geology and topography, and its diverse climatological setting with a wide range of temperature, precipitation and evaporation settings, California hosts some vital hotspot of biodiversity (Allen-Diaz, 2000). California has more than 4'800 native plant species of which 29% are endemic. The San Francisco Bay Area is one of these hotspots, however, the biodiversity of this human-altered ecosystem is at risk. As anywhere else in California, the main factors threatening biological diversity are human population growth and climate change (Allen-Diaz, 2000).

Switzerland

Biodiversity in Switzerland is also under pressure since it decreases continuously. The Swiss Federal Department of Environment (BAFU) confirms in its report dated July 2017 that more than half of the assessed natural habitats and more than one-third of the fauna and flora are threatened. Furthermore, a survey from

2013 shows that there is little awareness amongst the Swiss population on this topic and loss of biodiversity is not perceived as a life threat. The existing biodiversity seems to be overestimated and Swiss people falsely consider that there is a lot of diversity of plants in Switzerland. Studies have concluded that little knowledge of plant species diversity is available (Lindenmann-Matthies, 2008). Nature conservation is more about protecting species. Under the influence of the UNO Millennium Ecosystem Assessment, there is now a more interdisciplinary focus on the interaction between man and nature, to give space to both humankind and nature. This particularly makes sense in dense urban environments (Keller, 2017).

2.2 Types of green roofs

2.2.1 Definition

> "*A green roof is a layer of vegetation planted over a waterproofing system that is installed on top of a flat or slightly–sloped roof.* " (National Park Service, n.d.).

Other names for green roofs are vegetated or living roofs. In this paper the terminology for green roofs refers to green flat roofs or green roofs with little slope (<5%).

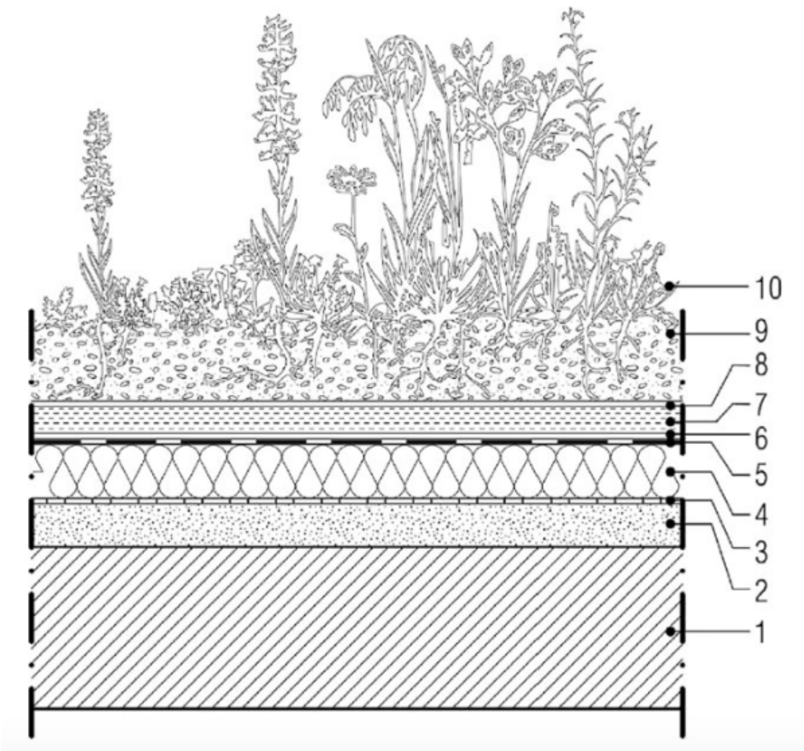


Figure 5: «typical construction of an extensive green roof In the drawing: 1) bearing structure, 2) draining slope, 3) vapor barrier, 4) thermic insulation, 5) waterproof membrane, 6) root barrier and mechanical protection, 7) drainage (and room for water storage), 8) filter, 9) vegetation supporting layer (and room for water storage) and 10) vegetation. The drawing was realised with Adobe Illustrator CS6 and was inspired by both the technical details and the drawings of the UNI 11235:2015 and the SIA 312-SN 564312:2013 standards" (Catalano et al., 2018, p. 17).

2.2.2 Green roof as habitat for flora and fauna

Green roofs provide appropriate habitat for fauna and flora, if once this fauna and flora reaches the roof, it can adapt to the local conditions (Brenneisen, 2006). Green roof habitats differ from habitats on the ground: the substrate layer is shallow with limited water and nutrient available (see Figure 6 to Figure 9). This has consequences for the vegetation. Since there is no connection to deeper layers, plants have little root space and the plant root systems have no access to groundwater. Therefore, only plants that have developed strategies to manage extreme dry periods can survive over time under these conditions. Due to the light substrate layer, less nutrients are available even though nutrition is also provided via air (Snodgrass & Snodgrass, 2006). Thus, lack of nutrients over time is possible. Wildlife encounters another habitat on green roofs as on the ground. Caused by the limited substrate depth, soil easily dries out during hot periods. As a consequence, ground-dwelling animals cannot escape to deeper layers, they cannot retreat and survive in more humid conditions (Brenneisen, 2006).

No connection to the ground

Also typical to this habitat is the isolation from the ground level. No ground connection enables only fauna that is mobile enough to reach the roof. It depends on the position and proximity to existing habitats as well as the capacity to spread of the single species if a green roof can be reached by fauna (Köhler, 1993).

Extreme exposure to climate: sun radiation and wind

Exposure to weather and (micro) - climate is more extreme on a roof than on the ground (Dakin et al., 2013). By reason of the high altitude on the roof, extreme wind conditions prevail, which can cause plants and substrate to dry out. Extreme sun exposure creates high surface temperatures in the soil. Both factors lead to increased evaporation of the vegetation layer. A wide amplitude cold-hot is another stress factor. Moreover, shadow rolls from ventilation systems or neighbouring buildings, for example, can block the sunlight. Frost and waterlogging are other stress factors, especially in winter. These site factors impact the choice of vegetation and the use of the roof. Secondary it also impacts the wildlife that can be hosted on the roof. Both flora and fauna need to be adapted to these extreme microclimates on extensive living roofs (Dakin et al., 2013; Dunnett et al., 2011).

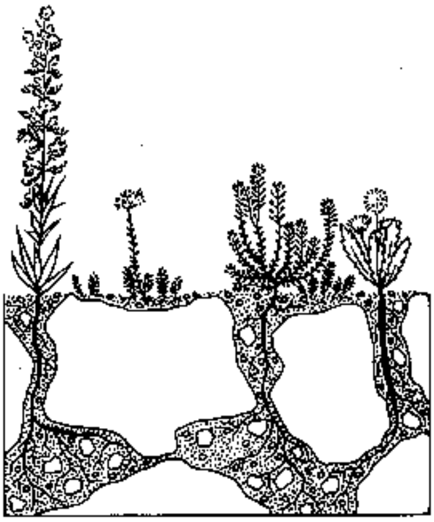


Figure 6: In a natural environment, plant toots have access to deeper layers and can reach ground water. Drawing: S. Erni

Figure 7: Ground connection enables Dudleja farinosa to get access to ground water. Sutro Ocean Beach near San Francisco. August 2, 2017. Image: L. Dierckx

Figure 8: On a green roof, connection to deeper layers are missing. Only plants that are adapted to these extreme conditions of little nutrients and water can survive over time. Drawing: S. Erni

Figure 9: Sedum album on the shallow substrate of a green roof test plot from Drew School, San Francisco. August 5, 2017. Image: L Dierckx

Low maintenance

Since these roofs are not meant to be accessed, and due to the low maintenance in terms of weeding, fertilizing and watering, green roofs can provide undisturbed life to its fauna. Furthermore, the natural dynamic of the vegetation is supported, and plant communities can establish over time (Brenneisen, 2003). Species and plant communities that are endangered by traditional intensive agricultural practices can colonize and thrive in green roofs (see Figure 10).

Low maintenance, natural soil and no fertilizer favoured endangered orchid species to establish. Their natural habitat disappeared to make place for urbanization (Brenneisen, 2006).

Figure 10: An example of a green roofs that provides substitute habitat due to low maintenance orchids have a chance to endure. The Lake Water Filtration Plant in Wollishofen (Zurich, Switzerland). With Anacamptis morio (green winged orchis). April 13, 2018. Image: L. Dierckx.

In its extreme range, climate and substrate conditions are responsible for stressing plants since the rate of photosynthesis is reduced. This has negative impact on a plant's growth (Tremp, 2005). Therefore, plants need to be self-sustaining and develop strategies that are adapted to these extreme conditions. They need to learn to become drought resistant. Typical plant strategies are leaf-succulence known at stonecrop species. Many ruderal annual species produce their seeds before the dry season and go dormant. Their natural habitat such as gravel and sandbanks on rivers are often threatened or disappear altogether. On green roofs, these habitats can be mimicked and become part of ecological compensation (Brenneisen, 2006).

Different animal groups use green roofs as habitat. The permanent colonization of fauna on green roofs depends on abiotic factors such as climate, structure and areal size (Köhler, 1993); biotic factors include mobility, food and resource requirements, competing pressure; and habitat quality related requirements are hunting and wintering facilities or retreat in hot dry summers (Köhler, 1993)

2.2.3 Classification

Contemporary living roofs can be categorized as extensive and intensive roofs (Dunnett & Kingsbury, 2004). A third category in-between both categories is a semi-intensive roof (Hui, 2013). The main differences are defined by the main intended goal, the substrate depth and the level of maintenance they require (Thommen, 1988; Brenneisen, 2003) (see Figure 11) A last category is biodiverse roofs, a relatively new typology of green roofs, defined by the main function to enhance ecological qualities and provide a diverse habitat for flora and fauna (Dunnett N., 2015; Catalano & Baumann, 2017).

Extensive	Semi-intensive	Intensive
3 to 6 inches deep	**6 to 12 inches deep**	**8 to 24+ inches deep**
Lightweight substrate, simple plant pallet or seeded. Usually low maintenance.	Lightweight substrates, varied topography, perennials and varied plant material. More maintenance required.	Varied topography and substrate depth. Applications include urban agriculture, garden roofs, sky park, traditional landscape, trees, and ornamental shrubs. Higher maintenance required.

Figure 11: different substrate depth creates different vegetation forms. (from left to right) Sedum-moss, sedum-moss-herbs, sedum-herb-grass. Drawing: S. Enri.

Extensive green roof

Extensive green roofs have shallow substrate and the maintenance is reduced to a minimum. Costs are kept low (Hui, 2013). They are often not made to be accessible, except for maintenance. The minimum thickness of the substrate is 7 cm, (Brenneisen, 2006) but depends on the climate and the amount of precipitation, taking also the load capacity of the roof into consideration. The maximum thickness of the substrate for extensive green roofs is defined differently by various authors and the maximum height varies between 10 cm and 15 cm (Hui, 2013; Snodgrass et al., 2006). The quality of the installation surges with increasing thickness of substrate (Kolb 1999) Figure 12 shows the growth form depending on the substrate depth. Little substrate consequently means little root space as well as little space for water storing. The result is that only host plants that are drought resistant or plants that can bypass the dry periods via their dormant seeds can survive. Volume of biomass will be low. Due to the shallow substrate, typical plant communities are moss-sedum-herbs and grasses. A successful monitoring study issued by the city of Zurich showed that a substrate layer below 5 cm over time will host only mosses, low growing Sedum plants and very few herbaceous plants (Brenneisen, 2007). The fully saturated weight of the construction is low (70- 170 kg/m2) (Dunnett & Kingsbury, 2004). Figure 5 shows the typical construction of an extensive living roof with the different layers.

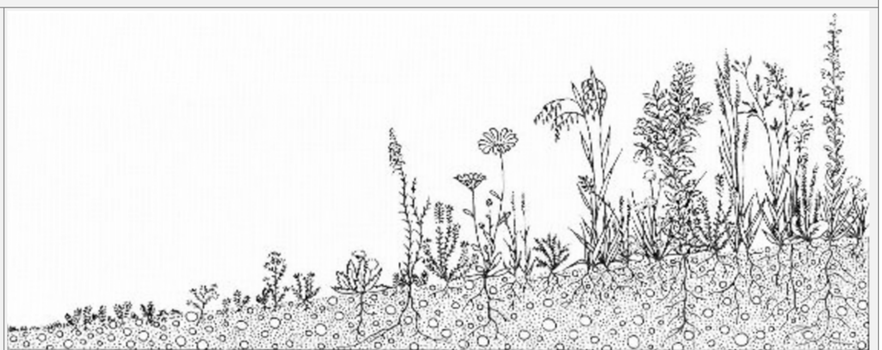
Intensive green roof

Intensive living roofs are constructed with a thicker layer of soil media, hosting not only annuals and perennials but also shrubs and trees. They consist of a > 15 (Hui, 2013) or 20 cm thick substrate, are normally more expensive and require high maintenance. They are typically irrigated. Often, they look more like a garden (Dunnett & Kingsbury, 2004) or a park, and are normally accessible (FLL, 1995). The fully saturated weight of the construction is higher, between 290 and 970 kg/m2 (Hui, 2013).

Semi-intensive green roof

A third category can be defined as semi-intensive roofs or simple intensive roofs (FLL, 1995), and they may be partially accessible. Plant diversity is greater than for extensive living roofs, mostly grass-herb and shrubs. Cost and maintenance vary. The fully saturated weight of the construction is low (170-270 kg/m2 (Hui, 2013).

Growth form on extensive green roofs



Appearance/ Phenotype	Rocky steppes (sparse vegetation)	Flower meadow (medium coverage)	Flower meadow with an increase of grass species (dense vegetation)	Flower meadow with grasses and perennials forbs (dense vegetation)
Substrate height after compaction	≥ 8 cm	≥ 10 cm	≥ 12 cm	≥ 15 cm
Vegetation form	Sedum sp., mosses and some forbs	Sedum sp., forbs and some grasses	Forbs and grasses	Grasses and some forbs

Figure 12: Vegetation development depending on substrate height and waterstoring capacity. Drawing: Geographical Institute University of Basel, Information sheet construction Department 2003 E. Will, S. Brenneisen

Biodiverse roofs

This category of green roofs considers in their design the ecology approach in terms of supporting a self-sustaining vegetation system. This means that the main specific scope of this type of green roof is to conserve and create habitat for flora and fauna as well as to attract pollinators. Furthermore, for mobile invertebrate species, they can act as stepping stones and therefore increase habitat connectivity (Kyrö et al., 2018). Use of natural substrate of the area that contains regional microorganism and mycorrhiza, encourage plant growth. On biodiverse roofs, varies microhabitats are created by variation of substrate height and the installation of little hills, each having a different availability of water. These modifications enable a variety of vegetation forms, that support the establishment of different plants and animal species. Hence, biodiversity and increase urban diversity is supported, more than when a uniform substrate layer is applied (Brenneisen, 2006; Catalano & Baumann, 2017, Rowe, 2015). Figure 13 and Figure 14 show diverse structured habitat creation for green roofs. "They can provide habitat compensation for rare and endangered species that are subject to habitat loss and become an instrument for ecological-compensation" (Brenneisen, 2006).

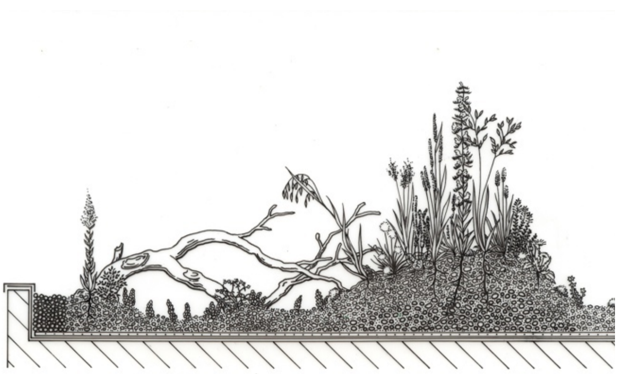


Figure 13: Diverse habitat on a biodiverse green roof: created by variation of substrate and substrate height, as well as different structures such as dead wood logs and branches. Drawing: S. Erni

Figure 14: Structural diversity offers many ecological functions and different habitat. For example, a protruding limb can be used by Phoenicurus ochruros (black redstart) as observation point for hunting prey, deeper substrate enables growth of forbs and grasses which offer habitat for insects, the bird's prey. Deeper substrate enables also retreat for invertebrates in dry and hot periods. Drawing: L. Dierckx

Catalano & Baumann (2017) synthesised the most specific design features for biodiverse green roofs:

Creation of spatial heterogeneity: Different thickness of substrate and different types of substrates

Different substrate thickness provides additional habitat to beetles, (Brenneisen, 2003). A thicker substrate layer can ensure the survival of beetles during periods of extreme drought. Furthermore, there is often a correlation between substrate depth and vegetation type (Kyrö, et al., 2018) (Madre, Vergnes, Machon, & Clergeau, 2013). Structural complex green roofs with structural complex vegetation show a higher species richness than roofs with low vegetation caused by limited substrate dept. Vegetation functions as food for fauna and abundant vegetation can shelter more species (arthropod communities) (Brenneisen, 2006) (Madre et al.,2013).

To increase spatial heterogeneity, it is recommended to:

- Varying substrate depth between 8 and 20 cm
- Create vegetation free areas and water outlets support xeric insects.
- Mix excavation soil with sandy-gravel from local pits.

Different types of substrate support different habitat and plant communities, thereby committing to urban biodiversity (Madre et al.,2013).

Selective plant selection: use of native plant species.

- The origin of the selected plant species needs to be from the local biogeographic region.
- A species richness of 6-10 species per square meters.
- Use of native species: This contributes to preserve the typical flora from the region and supports the insects that live in it.

If a species-rich meadow vegetation type is intended, Catalano et al., (2013) recommend the use of diaspore hay transfer from a donor meadow from the regional biogeographical region. This will ensure the highest plant species richness and diversity.

Use of Extra design features:

Also, dead wood, rocks and sand areas enhance the heterogeneity on the roof, which is beside the structural complexity of vegetation, an excellent way to enhance arthropod diversity (Brenneisen, 2006; Madre, et al., 2013).

It is recommended to:

- Design with stones, trunks (see Figure 15), pebbles (see Figure 16) and branches that provide extra habitat structure, create different microclimates and protect micro fauna against harsh weather conditions It enables the fauna on the roof to survive periods of extreme drought.
- Use of temporary ponds provide water to arthropods and birds.

Figure 15: Canton Hospital Basel: Dead wood provide microhabitats for flora and fauna. April 13, 2018. Image: L. Dierckx

Figure 16: March 26, 2017 Jacob Burckhardt-House in, Basel Image; L. Dierckx

Minimum maintenance and disturbance: To allow the natural dynamic of the vegetation, maintenance is reduced to a minimum, periodically, once a year. It includes:

- Checking the technical and structural element
- Removal of invasive weeds is recommended.
- On meadowlike green roof, one mowing per year is recommended and its nutrient rich biomass removed to keep the meadow nutrient poor. This favours wild species.

2.3 Benefits of green roofs

Green roofs are highly multifunctional landscapes, that means that many functions can be fulfilled simultaneously on a small space (Catalano & Baumann, 2017; Oberndorfer et al., 2007; Yang, Li, & Li., 2013). Together with facade greening, they offer ecosystem services and benefits with regards to air quality (filter air pollutants), better city and microclimate, high water retention capacity and stormwater management, mitigating heat island effect, increased insulation, increase the lifetime of a roof, protection of the building against damage, noise reduction and sound insulation, sequester carbon, and the flowers provide food for pollinators (Köhler, 1993). Moreover, green roofs increase the aesthetical value of a building (Minke & Witter, 1985). Furthermore, urban gardening on a green roof also commits to a social benefit (Hui, 2013) and can be a step towards local food security. Green roofs can provide a living example of a natural space that people can see, touch and understand. That way, urban ecology can be introduced, and visitors can learn about biodiversity and nature on the roof. They can watch how nature develops and see the changes. Table 1 summarizes the main public and private benefits.

(UAL: Central Saint Martins, 2017)

Table 1: Private and public benefits of green roofs (Catalano & Baumann, 2017; Clark et al.,2008; Dunnett et al., 2011; Dunnett & Kingsbury, 2004; Hui, 2013, p. 3 modified; Oberndorfer et al., 2007; Snodgrass & MCIntyre, 2010)

Public benefits	Private benefits
Aesthetic value	Aesthetic value
Mitigate Urban Heat Island effect	Reduce cooling loads, reduce Air Conditioning (Energy conservation) / Summer and winter
Stormwater retention	Contribute to green building rating credit points (e.g. LEED system)
Promoting biodiversity: Create new plant and wildlife habitat Habitat for rare and endemic plant and animal species, conservation value	Better use of space
Functional open space	Sound insulation, reduction of noise level
Agricultural space	Reduce risk of glare for surrounding building
Filter dust and pollutants	Increase roof lifespan (protect waterproof membrane),
Filter rain water	Food production: harvest vegetables, fruits and herbs
Compensation for loss of green space/ habitat on the ground	(re-) connect to nature, appreciating nature, take care of own environment
Learning environment: Educational classroom	Learning environment: Educational classroom
recreational space: wellbeing	Recreational space: Wellbeing
carbon sequestration (capturing carbon)	Increase value of the real estate
Integration in urban ecological network	

Thanks to their ecosystem services and the many other benefits that green roofs provide, local (Basel, Zurich), federal and national governments (Switzerland) have recognized their value. As a result, since last decade, green roofs have become part of building codes in many locations. That way, green roofs can unfold more of their impact: the more biodiverse green roofs are installed, the more the ecological benefits are to be expected (Dunnett et al., 2011).

2.4 Narrative Environment

2.4.1 Terminology

The term Narrative Environment is based on the term "Narrative Space" launched in the context of cinema by Stephan Heath. It refers to the combination of a visual form with a narrative content. The term Narrative Environment is strongly shaped by the Saint Martins College of Art and Design as well as the Design University of Arts in London (Mueller, 2011). In the introduction of the Degree Show Catalogue 2017 to the MA Narrative Environments of Saint Martins College, the following short clarification is given:

> "Narrative is a fundamental and accessible way for people to make sense of places."
> (UAL: Central Saint Martins, 2017 p. 5).

2.4.2 Narrative Environment in the context of the environment and sustainability

Müller (Mueller, 2011), in his Master thesis, incorporates Narrative Environments in the context of the environment and sustainability. He describes Narrative Environments as communicative environments created in space (environment), which allow for experienceable learning. Settings are originated to enable a new experience and view on nature and culture. Also, a profounder understanding of nature can be established (Mueller, 2011).The key element is the story (narrative) which interacts with the environment that is created. There is no intervention from a storyteller needed, the landscape (environment, spacial setting) built tells the story by itself.

Narrative Environment is an interdisciplinary method that connects the natural and environmental sciences with cultural, historical and social contents. According to Mueller (2011), the landscape with all its elements and the perception of the scene forms the foundation for a Narrative Environment. Therefore, the different aspects and factors of this context need to be analysed to elicit its potential and its suitability (see chapter 3). Narrative Environment supports systemic thinking and skill development (Mueller, 2011). Abstract knowledge and terms can be emotionally experienced (Baettig-Frey & Jaeger, 2018). It offers an experience-based way of learning: it does not only appeal to the brain, but also addresses many senses and touches emotions. The more senses are addressed, the more channels are available to absorb new information (Baettig-Frey & Jaeger, 2018; Inderbitzin & Harlinghausen, 2016; Jaeger, 2010) Therefore, Narrative Environment is an effective instrument to transfer knowledge in a context of environmental and sustainability topics.

Moreover, an effective analysis conducted with school classes, six months after they took a tour at Graeserland, a garden with Narrative Environment at the ZHAW Campus in Waedenswil, showed that students' gained knowledge was significantly higher than those of the control group (Baettig-Frey & Jaeger, 2018). Baettig-Frey & Jaeger (2018) concluded that knowledge transfer in a Narrative Environment could provide long-lasting effects. In this context, it can motivate students to a responsive attitude towards natural and cultural resources (Baettig-Frey & Jaeger, 2018; Mueller, 2011). Mueller (2011) confirms that Narrative Environment can be applied to all places and situations that enable environmental education. In environmental education, one of the outcome goals is to acknowledge and accept the intrinsic value of nature and the environment (Mueller, 2011). Müller suggests that Narrative Environment can help define nature images in a positive way that might lead to a more conscious action towards a sustainable environment. A choice of relevant topics (natural recourses, environmental changes, nature values and relationship to nature, consumption, and lifestyle) in nature education is shown in Figure 17. Biodiversity is one of the themes that can be communicated by the holistical approach of a Narrative Environment and it can open the visitor's eye for biodiversity and let it become part of his or her life.

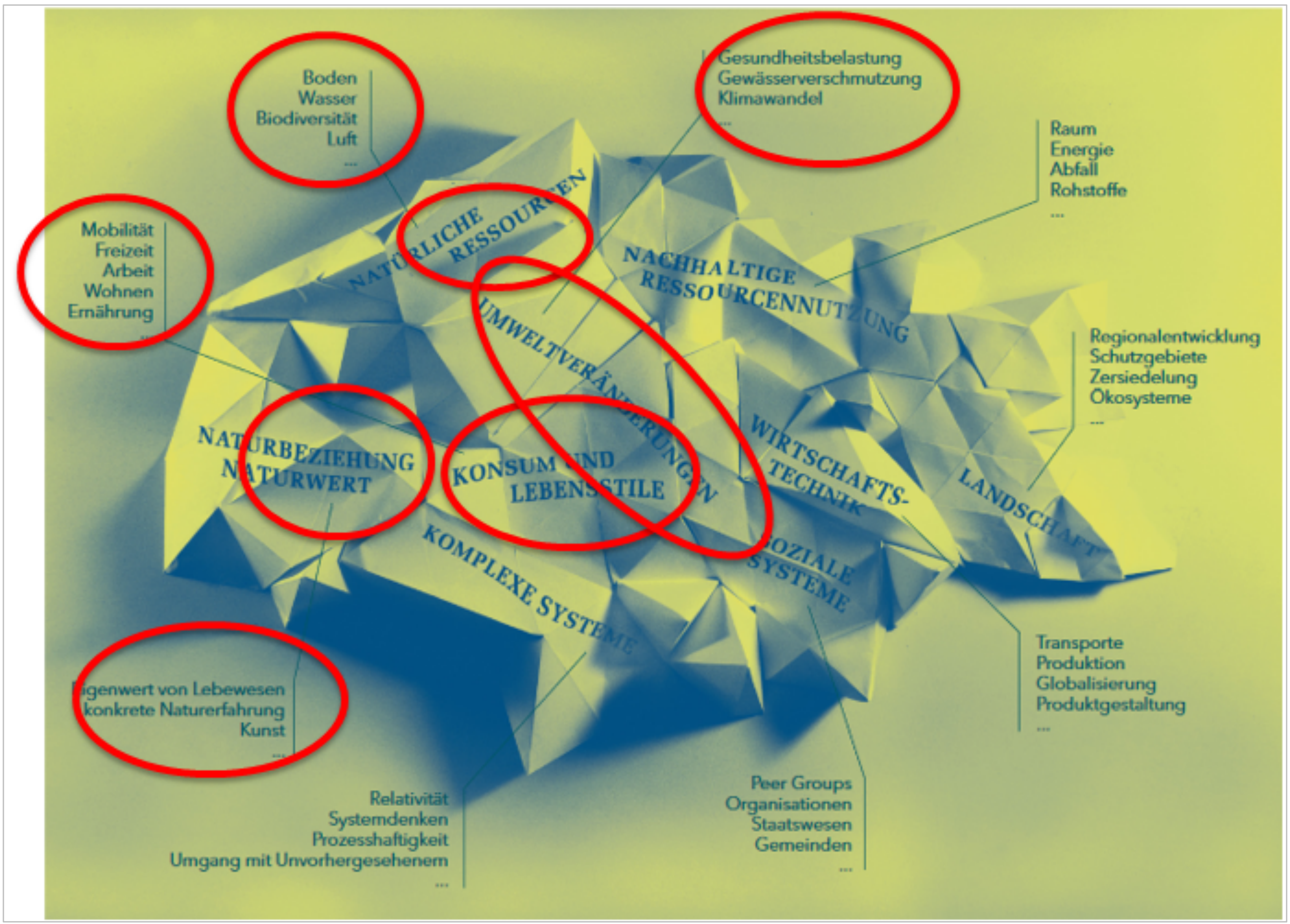


Figure 17: Range of topics related to environmental education. The items in the red circles show the topic and keywords relevant for the green roof environment. Image: (Stiftung Umweltbildung Schweiz, 2010) edited.

2.4.3 Green roof as educational space

Museum exhibitions and cultural events are considered as spaces for experience and lifelong learning (Mueller, 2011). Dakin et al. (2013) point out that green roofs can fulfil the same function. They can play an essential role in environmental education, including learning about dynamics in nature, biodiversity, rare or endangered species and ecosystems. Often, green roofs are created as an outdoor research classroom wherein the context of classes such as Ecology, Biology and Urban Agriculture students can develop and enhance environmental awareness. Such green roofs can promote practical learning experience (Yurek, 2013). A good example is the Drew School Roof in San Francisco, where students in the framework of an ecology class get the change to practice and learn research methods as well as native plants; as was witnessed by the author of this thesis.

2.4.4 Green roofs in a social-cultural-historical context

The analysis of the societal conditions is part of the process to create a Narrative Environment. It ensures that the Narrative Environment can be developed following the Zeitgeist in order to enable identification. In this context, it is also crucial to capture the actual trends and megatrends (Jaeger, 2010).

Megatrends show changes in society which characterize us since long and will further characterize us in the future. They can be seen as deep currents of change. As invariables of development, they last several decades. Each megatrend impacts each single individual and covers all levels of society (Zukunftsinstitut GmbH, 2016).

The Zukunftsinstitut recognizes twelve megatrends: Individualization, Gender Shift, Silver Society, Know-How culture, New Work, Health, Neo-Ecology, Connectivity, Globalization, Urbanization, Security, and Mobility (Zukunftsinstitut GmbH, 2016). Similarly, Dakin et al., (2013) value the design aspect on natural green roofs very highly and recommend including to study and observe the socio-cultural and historical context to define the design in order to enhance interaction between green roof landscapes and the audience. Dakin et al., (2013) refers to green roof projects such as the LAMOTH (Museum of Holocaust) roof in Los Angeles, where the analysis of the social context of the surrounding area was integrated into the roof concept.

3 Material & Methodology

As mentioned in the introduction (see chapter 1), this thesis investigates methods for the connection of Narrative Environments and green roofs with focus on promoting biodiversity. With this intension, this chapter presents two methodologies (a) Site Analysis and (b) Narrative Environment method. The first one is the methodology of site analysis that is used in the planning of secure, long-lasting and good functioning green roofs that meet quality standards. The second method is used to create a Narrative Environment.

3.1 Site Analysis

3.1.1 Definition of site analysis and usage

> "*Site analysis is a preliminary phase of architectural and urban design processes dedicated to the study of the climatic, geographical, historical, legal, and infrastructural context of a specific site. The result of this analytic process is a summary, usually a graphical sketch, which sets in relation the relevant environmental information with the morphology of the site in terms of parcel, topography, and built environment. This result is then used as a starting point for the development of environment-related strategies during the design process*" (EngineeringFeed, 2018).

Site analysis is an important method to help to define parameters for the design and construction of a green roof (Dakin et al., 2013). A combination of functional and technical approaches enhanced by the ecological approach, used in conservation science, is desired (Brenneisen, 2006). Since not all methods cover all these aspects, three different standard methods of site analysis from a different field are presented: (a) the site analysis after the FLL Guideline for Green Roofs, (b) Method Site Analysis (Inventory) from the field of landscape design and (c) Ecological Planning Method. Each method is derived from a different field being green roof construction (FLL), landscape design (Inventory) along with ecology (Ecological planning). Each method focuses on different aspects of site analysis that can be used for green roof construction. These methods are described, evaluated on their effectiveness as methods for designing green roofs. Lastly, the methods are compared in order to make a synthesis as a method (CoNaNalysis) that combines all those aspects.

3.1.2 FLL Guideline for Green Roofs 2008 (FLL, 1995)

The here presented site analysis is part of the German FLL Guideline for Green Roofs. These guidelines for green roofs are designed to inform about state-of-the-art performance expectations for green roofs. Since they are used worldwide as a standard by most suppliers and constructors (Hui, 2013) (Snodgrass & MCIntyre, 2010), it is worth looking into it in this paper. As shown in Table 2 there are three sections that need to be analysed: 'Climate and Weather', 'structure' and 'Installations'. Under the heading 'Structure and Installation', the analysis includes important technical and structural research to confirm a safe and proper construction.

The structural load factor is central, as it defines which type of green roof can be installed (see chapter 2). Besides these structural considerations, also the climate and the weather as well as two abiotic factors are analysed. The retrieved information can help to select the optimal substrate and ensure a plant selection adapted to the site. The author added the 'source of information' in the table to find out how to get this essential information.

Table 3 shows the evaluation of the strengths and weaknesses of this method.

Table 2: Site analysis after FLL 2018. (Hui, 2013). The author added the column source of information.

Factor	Details	Source of information
Climate and Weather (abiotic factors)	Regional Climate	Research
	local microclimate	On-site Observations, Research,
	pattern and amount of rainfall	Research
	shadowing effect of surrounding building	On-site Observations, Map
	average exposure to sunshine	On-site Observations, Research
	Any incidents of periods of droughts	On-site Observations, Research
	Airborne contamination	Research
	Extreme proximity to sea or high on a mountain	Research
	Direction of prevailing wind	On-site Observations, Research,
Structure	Design loads for the roof structure	Structural engineers, architectural maps
	Exposure to roof surfaces	Structural engineers, architectural maps
	Gradient of slope of the roof surfaces	Architectural maps, Measure
	Existence of any major plants and exposed pipework on the roof	Architectural maps

	Areas exposed to the sun and shade areas	Architectural maps, On-site Observations
	Deflection of precipitation by the structure	Architectural maps
	Wind flow conditions and wind uplifting effect	Research, On-site Observation, Architectural maps,
Installation (plant)	Current drainage arrangements on the roof	Architectural maps, On-site Observations
	Water requirements	Architectural maps, On-site Observations
	Power supply requirements (for lightning and equipment)	Architectural maps, Observations

Table 3: Evaluation on their effectiveness as method for designing green roofs. L. Dierckx

Strengths	Weakness
Includes structural and installation analysis which can ensure safety and proper technical installation.	Thematic approach, Process steps missing
Includes abiotic factors that can help define vegetation	Biotic factors on-site and of the environment are left aside (Ecological factor) Needs from ordering party and target audience are left aside (Socio cultural factor)

3.1.3 Method Site Analysis (Inventory) from the field of landscape design

This Site Analysis method or Inventory is used for any garden design and landscaping, with the aim to create a long living planting that suits local conditions (Bouillon, 2013; Trachsel, 2016). Moreover, it enables to find a selection of plants that match the location and can therefore be integrated into local surroundings. Plant designs can only be successful and sustainable if species as well as genus-specific site needs are considered (Bouillon, 2013). Bouillon (2013) and Trachsel (2016) both consider the analysis of abiotic (e.g. climate) and biotic (e.g. human beings) site factors in order to successfully design with plants and perennials. Each design starts with an analysis of the starting position. It includes the study of the location and the surrounding environment, interpretation of its features and results in defining a theme for the new design. This method distinguishes between hard and soft factors. Both are considered in the analysis (see Table 4). Table 5 evaluates the strengths and weaknesses of the method.

Table 4: Inventory based on Bouillon, 2013; Trachsel, 2016.

Preparatory Phase			
Factor	Questions to clarify	Source of information	Biotic/ abiotic
Background materials	Inventory plan, cadastre plan, pipe plan, situation plan, photo documentaries	Research and plans	n/a
Climate	Macroclimate, Mesoclimate, microclimate (Light/ Temperature)	Research and observation	abiotic
Microflora and fauna	On and around the site	Research and observation	Biotic
Hard factors			
Location Vegetation Habitat			
Factor	Questions to clarify	Source of information	Biotic/ abiotic
Substrate / Soil	Soil condition, humidity rate, need for soil upgrading? Type of soil, particle size distribution, humus content, PH-value, mineral nutrient, heavy metal content, water holding capacity, water permeability	Research and observation	abiotic
Light conditions	What is the amount of sunlight?	observation	abiotic
Wind	What is the main wind direction?	Research and observation	abiotic
Orientation	What is the orientation of the green space?	observation	abiotic
Plant habitat: Light rate and humidity rate	What are the light conditions and the humidity rate?	Research and observation	abiotic
Strategy types	Which strategy types can be used?	Research and observation	n/a
Extreme sites, problem zones	For example: Are there plots that are extra dry, extra moist, extra windy?	Observation	abiotic
→ Result: Drawing: recording vegetation and classification of plants			
Location: Existing vegetation			
Condition of the existing vegetation	What plants need to be kept, which plants need to be replaced and why?	Observation, interview, Research	n/a
→ Result: Drawing: recording vegetation and evaluation (assessment) of plants			
Location: Building space and walkway system			
Building space	How is layout of paths? Does it make sense?	Observation, Interview	n/a
Connections, perspective lines, spaces	Are spaces available? How is space created? Are they located at the correct location? Is there a need to create new space by pants or emphasis existing space by plants? Which type of space is wanted? (depends on use and needs): Do the exist already or do they need to be created?	Observation, Interview	n/a
Structural elements	Buildings, walls, fence or railings	Observation	n/a
Topography	Different altitude	Observation, maps	abiotic
→ Result: Drawings: left: walkway system the ticker the arrow, the more frequented/ right: space arrangement			

Factor	Questions to clarify	Source of information	Biotic/ abiotic
Environment: Surrounding area			
Neighbour building	What is the style of the neighbour building?	Observation	n/a
Urban qualities	Which urban qualities does the area have?	Observation	n/a
vegetation	Which plants are found in the surrounding area?	Observation	biotic
→ Result: Drawings: Vegetation mapping and evaluation of vegetation.			
Visual axis: Inside and outside views	Is sight protection available? Is it desired? Are visual axes with the environment considered? Where are insights allowed, where not?	Observation	n/a
→ Result: Drawings: left: inventory views and visual axes. Right: analysis views and visual axes			
Soft factors: location and environment			
History and development of the location	What is the history of the location? How did it develop?	Interview	n/a
Users / Use	Where is the location of utilization? Does the utilization take place at the intended location? Is there a lack of space for utilization? Who are the future users? Which utilization will take place in this green space? Which features does the planting need to fulfil to meet the planned utilization? → Draft: Analysis of utilization intensity →Draft: Type and site of utilization	Interview	n/a
Social and cultural framework & Architectural framework and urbanistic surrounding conditions.	Typical features of the environment: customs and traditions, Landscape, Vegetation	Interview	n/a
Requirement assessment: Interview with client (ordering party and /or target audience)			
Main function of the green space	What is the main function of the planting?	Interview	n/a
Type of green space Maintenance resources	Which type of green space is desired? How much time do you have for the maintenance?	Interview	n/a n/a
Duration	What is the expectation in terms of lifetime of the vegetation at this location?	Interview	n/a
Personal style, Creative and design demands	What are your tastes and preferences in terms of colours, favourite plants?	Interview	n/a
Economical demands	What is the budget available?	Interview	n/a

Table 5: Evaluation on their effectiveness as method for designing green roofs

Strengths	Weakness
Includes abiotic and biotic factors → can help define vegetation → ecological factor	Does not include structural and installation analysis
Includes interview with ordering party and target audience → Socio-cultural factor	Process steps missing
Intermediate stages of the analysis are well documented which helps the design process	Very detailed and time-consuming analysis. Some steps can be shifted for the green roof analysis

Even if this method is not specifically intended for green roof design, it can be used for that purpose, as the method gives neither constraints about which type of planting (native or cultivated) nor about the size or location of the site. Hence, it can be easily adapted to all different types of green roofs. Some amendments might be needed to comply with the specific needs of a green roof. If done properly, the results of this site analysis have consequences for the design and plant choice for the roof. It provides relevant parameters to find the correct plant communities and perform a plant selection that suits to the location (Bouillon, 2013). Additionally, it can help to predict the type of succession (Kühn, 2011). Including the socio-historical and cultural context helps to find a theme for the Narrative Environment. The Interview with the owner and or user enables to match expectations in terms of style, purpose and maintenance. The lack of structural analysis can be compensated by adding these factors from the FLL analysis.

3.1.4 Ecological Planning Method

The ecologic planning method is regarded as pioneering in the field of landscape architecture and urban planning (McHarg, 1992). It focuses on the ecological aspects and geographical context. The method is based on the consents that nature and humans are connected. This needs to reflect this in the design of the human environment, by means of taking surroundings, ecosystem, and climate into account. Dakin et al., (2013) suggest this ecological site analysis method for the design of green roofs, while this approach demonstrates that rooftops are an important element in the urban ecological system. Rooftop landscapes need to be understood as landscapes that are connected to the ground and its surrounding environment (see Figure 18). The site analysis is built up as a ‘layer cake’ (Dakin et al., 2013) that consists of six different levels, representing the six factors to consider. It starts with geology followed by meteorology (climate), then hydrology, soils, vegetation and Wildlife (Flora and Fauna) and Land Use (socio and cultural context) as a last layer (see Table 6). In Dakin et al., (2013), the layers are specified for the use of a green roof ecological site analysis. They amend the analysis with the core question that needs to be posed by the designer and the ordering party: “What do you want the roof to do for you?” The answer to this question directs them to the main function(s) of the green roof and helps to guide the observations on-site, the collection of appropriate data for that specific location. For example, the main function of a green roof can be the reduction of stormwater runoff, but it can also be a space to watch nature, or a place to grow food. Since green roofs are multifunctional green spaces, several simultaneous functions are possible. The evaluation on the strength and weaknesses of the method are shown in Table 7.

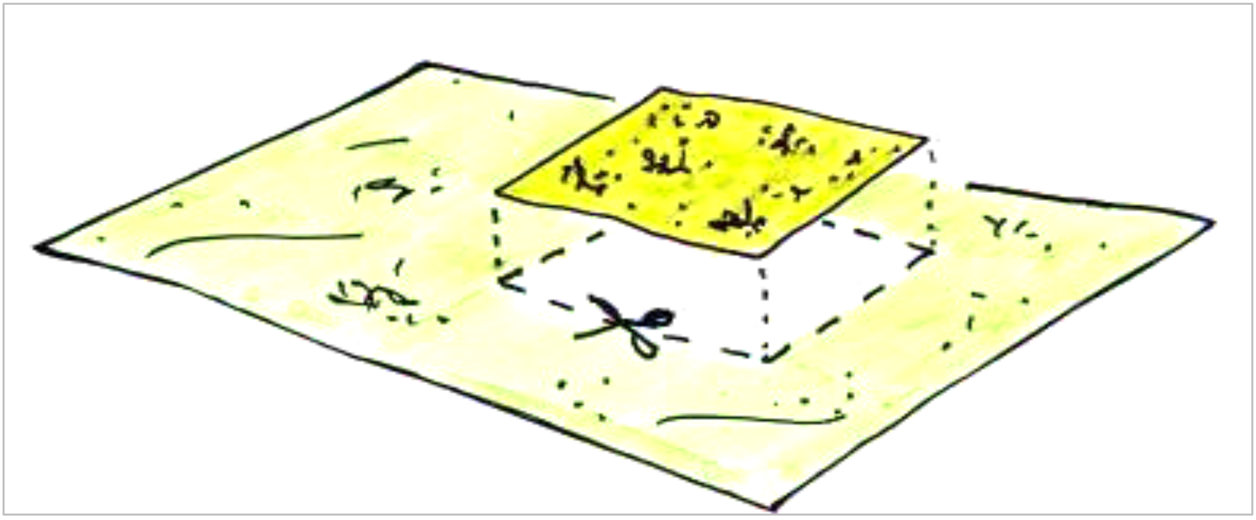


Figure 18: Site analysis: this visualization shows that green roofs are connected to its surrounding environment. Drawing from journal Garten und Landschaft 10/2003

Table 6: Ecological site analysis after Dakin et al.,(2013) and McHarg, (1992).

Location Vegetation Habitat			
Factor	Questions to clarify	Source of information	Biotic/abiotic
Regional Geology	What is the bedrock and strata of this area?	Research and observation	abiotic
Meteorology, Climate (as extreme site)	Weather, Wind, Sun Precipitation (rain, snow, hail) Temperature, Tornadoes Earthquakes, Microclimates seasons	Research and observation	abiotic
Soils	Analysis of the first layer of rock or of other geological formations.	Research and observation	abiotic
Hydrology	How much water is received from rain, sleet snow and morning dew or fog?	Research, observation, and measurement	abiotic
Vegetation and Wildlife	“What flora and fauna did historically exist, exists now, and are possible in the future?”	Research, architectural map and observation	biotic
Land use (Social, historical and cultural context)	Wat is the human and social interaction? Study patterns of people.	Research and observation	n/a

Table 7: Evaluation on their effectiveness as method for designing green roofs

Strengths	Weakness
Includes abiotic and biotic factors→ can help define vegetation→ ecological factor	Does not include structural and installation analysis.

Includes interview with ordering party and target audience → Socio cultural factor	Process steps missing.
Questionnaire helps the design process	Very detailed and time-consuming analysis. Some steps can be shifted for the green roof analysis.

3.2 Narrative Environment Method

As mentioned in the introduction of this chapter, the second method is used to create a Narrative Environment (in the context of environment and sustainability).

This method is based on Jaeger (2010, 2017) and Mueller (2011). Mueller (2011) and Jaeger (2017) focus on the different phases of creating a Narrative Environment. Additionally, Jaeger (2010) provides more detailed guidance on the creation process for Narrative Environment concepts by use of creativity methods.

3.2.1 Phases to create a Narrative Environment

To create a Narrative Environment, five phases are needed (Jaeger, 2017). The single steps are clarified following the method instructed during the Module Narrative Environments as part of the undergraduate study of Environmental Engineering at the ZHAW in Waedenswil (Jaeger, 2010).

Analysis

Phase 1: Analysis which focuses on project mapping, ordering party, target audience, target orientation and evaluation. In order to create a Narrative Environment two critical factors in the analysis are:
1). Find out who the ordering party is and who the target audience will be.
2). Detect what the immediate socio-cultural surrounding is.

Concept

Phase 2: Concept development: from idea finding to concept: Via research and creativity methods (+ Feedback) three concepts are drafted.
Phase 3: Concept formulation: Decide for one concept out of three. → Research and creativity methods → refine one concept that will be implemented.

Realisation

Phase 4: Project implementation
Phase 5: Project initiation and evaluation

Similar to Jaeger (2017), Mueller (2011) created a catalogue of criteria. He distinguished three phases:

Phase 1: Analysis

Phase 2: Idea finding, and development (concept)

Phase 3: Realization

Mueller (2011) mentions and describes the single work steps to create a Narrative Environment in the context of the environment and sustainability. Specific questions to discover the wishes of the ordering party and future users can help to get clarification on the specific factor (Jaeger, 2010). Table 8 shows the different phases, the working steps as well as the questions to be answered to proceed with creating the concept. Depending on the actual situation, not all questions might be answerable, and new problems might arise. Therefore, this list is not concluding, but it intends to cover the most relevant items.

For this paper, it is not planned to implement the Narrative Environment concept on a green roof. Hence, phase 4 and 5 will not be further explained. They are mentioned for the sake of completeness and to get an idea of the full cycle of a Narrative Environment. Phase 1 and phase 3 are elaborated in detail. The financial aspects, the time management, quotes, and the clarification with third parties are beyond the scope of this paper.

Table 8: Catalogue of criteria and working steps to make a concept and realize a Narrative Environment in the context of environment and sustainability. Based on (Jaeger (2017) and Mueller (2011).

ANALYSIS		
PHASE 1 ANALYSIS (Project mapping, ordering party, target audience, target orientation and evaluation)		
Working step	Description and goals	Question asked
Socio-cultural and historical context (environment)	Capture the zeitgeist, actual trends, prevalent values in different milieu of society. Together with the surrounding landscape they have a direct and indirect impact on the creation of the Narrative Environment. The goal is to elicit the site and suitability and potential of the location.	What type of location is it? What are the cultural and natural assets on-site? What are the political components? What is the history of the location? What are the dimensions of the landscape? Which elements are disturbing? What is the atmosphere of the location? Which megatrends are present or relevant?

Working step	Description and goals	Question asked
Framework condition and contract (not applicable for the creation of a new Narrative Environment)	Capture information about parties involved such as architects, artists, designer, age of the project, background on the project, to enable a professional approach.	What is the theme of the contract? What are the framework conditions? Who is involved in the project?
Ordering party	This is also a framework clarification. Getting the right picture enables to adapt the Narrative Environment to the needs and requirements of the ordering party and not miss the mark. Ordering party and target audience can be the same, for instance.	Who is the ordering party? Which are their values? Which projects exist already in this field? Are there existing similar projects from the ordering party? What is the field of activity of the ordering party? Does the ordering party use already specific technologies and communication media?
Target audience	Create a profile of the target audience based on the questions in column 3. Typical distinguishing criteria are: age, sex, cultural context, affinity to nature, motivation to learn, origin and relevant existing knowledge.	Who is the target audience, what and where do they work? What are their hobbies? Where do they travel to? What is their lifestyle aspiration? What are their values?
Goal of Narrative Environment	What is the goal? Adventures for the audience? Transfer of knowledge? Sensibilities on certain aspects? Built competence related to environmental education or education for sustainable development? Develop new or specific images of nature? Change behaviour of the visitors?	What is the short-term goal? What is the long-term goal? What can the audience learn and experience? What is the take-home message of the Narrative Environment?
Material specifications on-site	This helps to incorporate site specific elements in the Narrative Environment.	What material is available? Which material can be used? Which additional material is needed?
Financing, budget, time management	Needed to ensure the project can be realized. Can the full costs be covered?	What is the project budget? What are the financial resources for this project?

	Can sponsors be found? Can revenue be made? Can funds be raised? A business plan is required.	
→ Outcome: Moodboard concerning the existing themes.		
CONCEPT		
PHASE 2: Concept Development		
Working step	Description and goals	Question asked
Research Story/ Narrative	Research about the theme. Find stories (narrative) or create stories. Collect reference images and texts. Look for existing Narrative Environment. Find analogies. Research about material and products to materialize the narrative part.	Does the idea fit to the location, the story of the location, relations and identity?
Idea finding with creativity methods	See 3.2.2.	See 3.2.2.
→ Outcome: 3-10 Project ideas based on Research and creativity methods		
Research (further development of three ideas)	Further creativity methods. Collect images, facts and stories. Build model. Find ideas for materialization.	Is the target audience addressed? Are the goals clearly defined? Is the story recognizable? Is the idea feasible?
→ outcome: 3 concepts		
Creativity method	See 3.2.2. Decide for 1 concept	Is the effect strong enough but not too much?
→ outcome: 1 concept		
PHASE 3: Concept formulation		
Working step	Description and goals	Question asked
Project details on Story / Narrative, experience setting and orchestration, Exhibition concept and methods	Graphics, objects Material, tools, supplier User story, Model, maps Quotes and service third parties Finance, to do's and time management	Are visitors incorporated? Does it appeal to the cognitive senses? 4 communication strategies: Clarity, Action oriented, Wholeness, Differentiating
→ Outcome: concept board		

REALISATION		
Phase 4: Project implementation		
Working step	Description and goals	Question asked
Production and test	Supply material Built object Design surfaces Implement graphics To do's and time management Visitor guidance Marketing and communication according to target audience	n/a
Phase 5: Project initiation and evaluation		
Working step	Description and goals	Question asked
Plan presentation and introduction	Event, opening event Present contents and process to ordering party	n/a
Plan Implementation		n/a
At this stage the Narrative Environment is realized and presented at his location. Feedback and Evaluation		

3.2.2 Creativity methods

With the intention to find ideas for the Narrative Environment concepts, different methods of creativity techniques are recommended: these methods can help to activate and stimulate the creativity process. Additionally, they can bring incoherent or fleeting ideas together in order to carefully draw up original and unique concepts for Narrative Environments (Jaeger, 2010). These methods are very effective in the concept development phase. Jaeger (2010) proposes six of them. Table 9 shows those different methods, followed by a short description. The column 'how applied' clarifies if it can be applied as a single person or in a group.

Table 9: Creativity methods after Jaeger (2010) and Alder & Brock (2012).

Method	Short description	How applied
Brainstorming	Create new ideas	within a group
Brainwriting	Create new ideas variation of brainstorming	single or within a group
Mind Mapping	Create new ideas around one topic, variation of brainstorming	single or with two people
Idioms and expressions	Via brainwriting or internet Helps to break through conventional thinking	single or with two people

Moodboard	Present ideas and concepts visually. Shows immediate which elements fit together and which do not.	single or within a group
Pairwise comparison	Subjective method to find the best solution among equal options. Decision making criteria need to be made transparent. Pairs are compared and rated between 0 and 2. The idea with the most valuations is chosen.	single or within a group

Mind Mapping (Jaeger, 2010)

The creativity method individual “Mind Mapping” (Jaeger, 2010) is an effective method in the concept phase to generate project ideas and to draft the first concepts. Mind Mapping as a creativity method is perfectly suitable for visual-oriented individuals, mainly when a central theme is defined. Therefore, it qualifies for creating concepts and can be used to generate new or unusual ideas or for sorting thoughts out. This technique uses key words which release associations in the brain, leading to further ideas. Ideas are connected with arrows. Main ideas are highlighted or circled. The result is a net-like construction with terms, ideas, and drawings (Alder & Brock, 2012; Jaeger, 2010; OpenGenius Ltd., 2018) To decide for one final concept idea, the creativity method Mood Board or pairwise comparison can help in evaluating the ideas created through the Mind Mapping.

Innovation Styles Model

Once the final concept idea is found, it needs to be refined to a concept that can be realized. For this process, Jaeger (2010) proposes the Innovation Styles Model, which concerns four techniques for modifying, visioning, exploring and support innovations processes. Table 10 gives a short overview of the Innovation Styles Model after Miller. The visioning techniques *History of the Future* is clarified more in detail: this technique helps to generate precise ideas by imagining the ideal project results and the way to get there. It can be used after having decided on the one concept of Narrative Environment. In this stage, the concept ideas need to be refined and matched optimally to each other.

Table 10: Explanation of the Innovation Style Model after William Miller, based on Jaeger (2010) modified

Method (technique, Style)	Short description	How
Modifying methods	Modify and improve existing ideas. Starts with collection of facts and details. Build on already existing ideas.	Three techniques: *Force Field* after Kurt Lewis, Attribute Listing, and SCAMPER
Method (technique, Style)	Short description	How
Experimenting	Collection of facts, and details, new combination of existing aspects	Two techniques:

		Matrix analysis and Morphological analysis
Visioning techniques can be used to develop ideas by creating a mental picture in the future:		
Visioning	Start with an intuitive thought, a finding or hypothesis. Afterwards information is collected to confirm the intuition. A clear realistic image in the future is drafted.	Two techniques: Alter Ego History of the Future
Exploring	Start with an intuitive thought, a finding or hypothesis. Afterwards information is collected to confirm the intuition. A metaphoric image is drafted.	Two techniques: Nature symbol, Forced association or Forced relationship

History of the Future

The goal of *History of the Future* is for an ideal result to be imagined, so the way to get there can be elaborated. The procedure works as follows: assume that the local newspaper writes an article about the new Narrative Environment on a roof. The project is reported very enthusiastically. Which positive points are mentioned? Examples could be fun, enthusiasm, unique, stunning, visitor rush. In a next step, you tell the journalist the story of how you got there. Hence, you tell the history of the future to clarify the idea and all elements and project aspects of this concept and how these have led to this exclusive success story. From these notes, (story) ideas and goals for the project can be deducted.

4 Results

4.1 CoNaNalysis

The research question of this thesis is "*How can incorporating a Narrative Environment into the design of biodiverse green roofs as a method provide guidelines for the design of biodiverse green roofs in a socio-cultural context?*". To address this research question, a method was developed and experimented with. In regard to this method, the methodologies described in Chapter 3 were taken into close consideration. The author has evaluated these site analysis methods and applied them in the context of a green roof. With this base, and amended with the methods for Narrative Environments, a method for creating biodiverse green roofs with a Narrative Environment is constructed.

In light of this perspective, this paper develops a method called CoNaNalysis. This name refers to Concept (**CO**), Nature (first **NA**) and Narrative Environment (second **NA**) as they are all three the key components of the analysis. It is tailored specifically for the design of green roofs. It aims to create space for nature on a roof as well as space where people can interact with their environment. Thus, CoNaNalysis tries to bridge the gap between nature and culture. Hence, it attempts to generate a stronger connection to the location and include an esthetical and educational value. These benefits could build the added value of the Narrative Environment to the natural and ecological significance of a biodiverse green roof. As illustrated in Figure 19, the CoNaNalysis is created to be applied in the context of a biodiverse green roof. It starts with the site analysis for green roofs in its structural, functional, and ecological aspects, and integrates elements from the site analysis for a Narrative Environment. It is followed by the creative methods used for designing concepts for Narrative Environments.

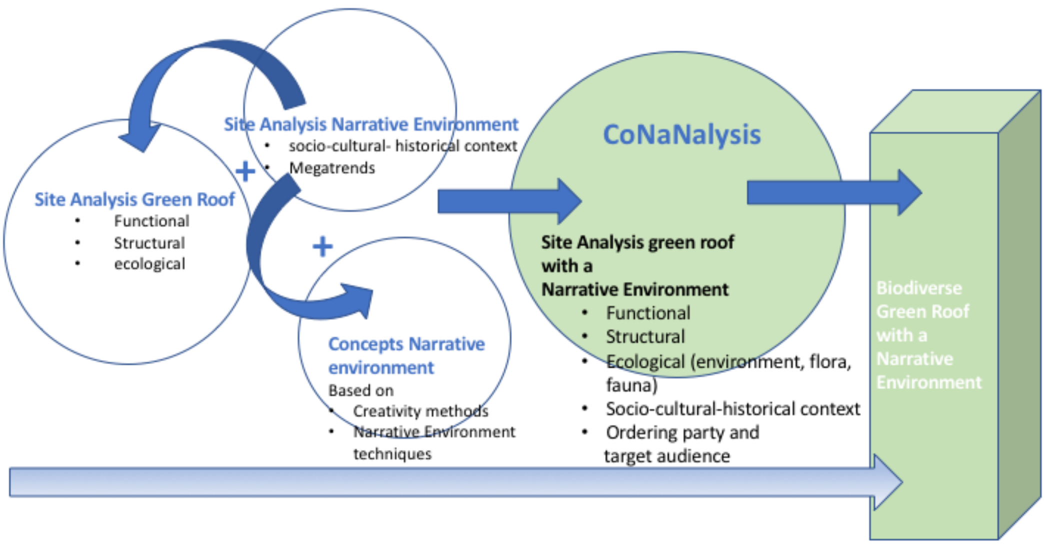


Figure 19: Component of the new method CoNaNalysis: Site analysis and Concepts Narrative Environment. L. Dierckx

To recap, the goal of the site analysis is to identify and consider all factors that might have an impact on the construction, on the choice of vegetation and the substrate, and on the final design and maintenance of the Narrative Environment on the green roof.

Evaluation of the site analysis methods

As mentioned in the introduction of this chapter, the different site analysis methods were evaluated, to create a site analysis that is tailored for the creation of green roofs with a Narrative Environment. Criteria for this evaluation of the site analysis were completeness, 'easy to apply' as a method and involving ordering party and target audience. Completeness refers to covering structural, installation, ecological and socio-cultural elements. Table 11 shows the different site analysis methods. The results of the evaluation illustrate that all schemes provide valuable information for green roofs, yet none of the method is complete to cover a detailed site analysis in the context of a biodiverse roof.

Table 11: Evaluation existing site analysis methods from Chapter 3. Unweighted Rating: ++= very well covered, += covered, - = lacking.

Criteria for evaluation ----------------- Site analysis method	Structural	Installation	Ecological	Socio-Cultural-historical	Easy to apply (Process steps, questionnaire)	ordering party & target audience involved
FLL (F)	++	++	+	-	-	-
Inventory (I)	-	-	++	+	++	+
Ecological (E)	-	-	++	++	+	+
Narrative Environment (N)	-	-	+	++	++	++
Results	**Keep F**	**Keep F**	**Combine I and E**	**Amend I with E and N**	**Amend E with I and N**	**Combine I, E and N**

4.1.1 CoNaNalysis: Tailored site analysis in three steps

The site analysis as part of CoNaNalysis contains elements derived from the above results. Additionally, it adds elements that are specific for the site of a green roof. The method is structured as a guideline with questions that help to correctly route the research and observations. It follows different process steps that are clarified below. As shown in Figure 20, three main successive steps can be identified:

- Off-site research
- On-site observation of the area
- On-site observation of the roof

Although it is recommended to successively follow these steps chronologically, multiple visits and research can be needed to get all the required information. Likewise, not all factors need to be considered and not all questions required to be posed, depending on the local actual situation and the experience, as well as expertise of the creator of the concept Table 17 to Table 20 with the details to those three steps can be found in Annex A.

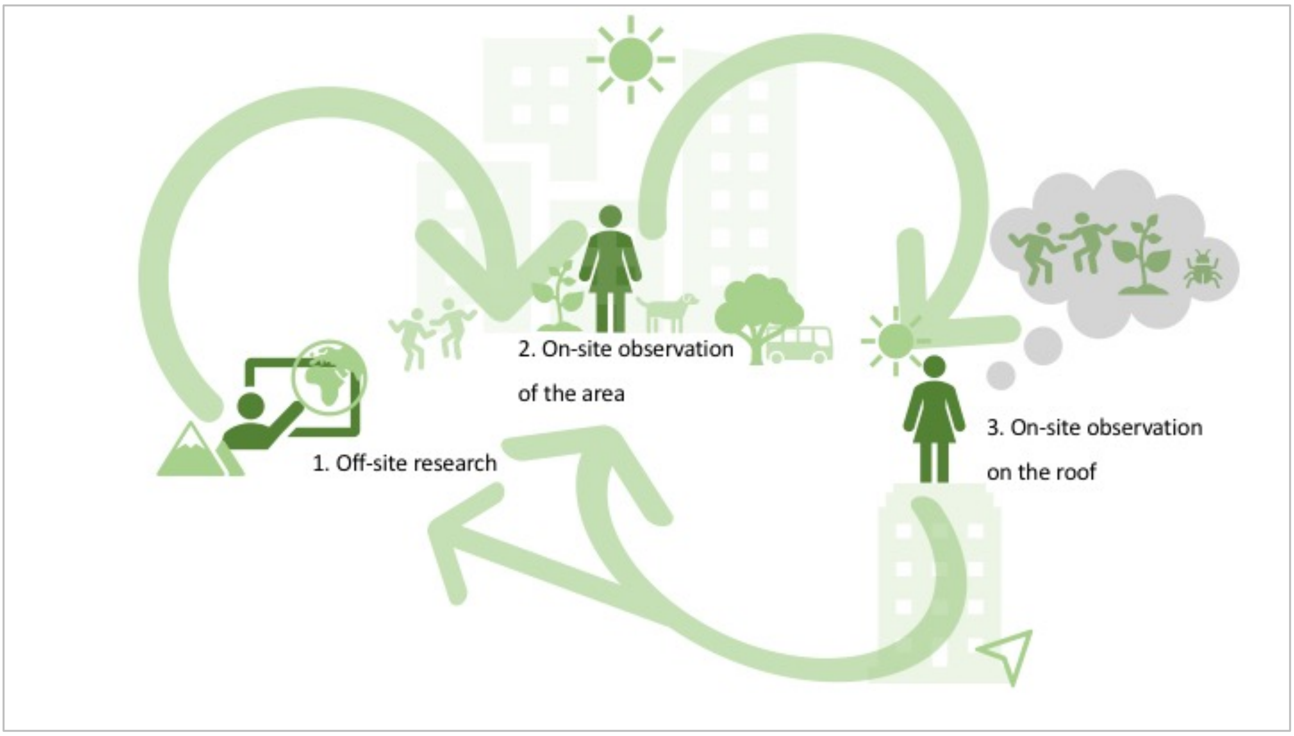


Figure 20: Three steps in the site analysis process of CoNaNalysis: Off-site research, on-site observation of the area and on-site observation on the roof. Creation in Microsoft PowerPoint for Mac Version 16.17. L. Dierckx

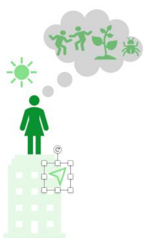
Step 1 of CoNaNalysis: Off-site research

The off-site research enables to retrieve information concerning the structural and installation elements for the green roofs. Through research, study of maps and measurements, relevant factors concerning the biotic and abiotic environment as well as the socio-historical and cultural context can be retrieved. Project documentation and interview with the ordering party and/or the target audience can help to find the approach for the Narrative Environment.

Step 2 of CoNaNalysis: On-site visit of the area

The next step is to visit the area, analyse, and observe the environment. This step helps to link the researched information to the area. Measurements can be done but also the environment can be experienced through as many senses as possible, which gives a more complete picture of the site than by off-site research. In this context, the word 'area' can refer to three different scales identified by the spatial extent. The smallest scale applies to the site around the building where the green roof is located. On a next level, the neighbourhood around the site is considered as the area of research and observation. Moreover, the largest area scale is the entire city. All types of areas are useful to study, with the purpose of getting a context-sensitive picture of the natural and socio- cultural context. All information can be helpful for designing nature on the roof as a Narrative Environment.

Step 3 of CoNaNalysis: On-site inspection on the roof



The last site analysis takes place on the roof. Also, here preliminary research helps to refine and verify the observations done. When possible, it is useful to meet the owner and user of the building and the roof there, as being in this atmosphere it helps to define goals and expectations. Also reaching out to the architect and structural engineer can help to clarify the structural and installation issues. If no visit to the roof can be made when the building is still under construction, the other two steps gain more importance. It is recommended to document the visit with photos, drawings, and notes.

To summarize: The CoNaNalysis site analysis enables to identify the site conditions in its natural, socio-cultural and historical context. It provides detailed information on the biotic and abiotic factors that define the type of substrate and vegetation on the roof to create a long lasting, self-sustaining, biodiverse green roof. It should be clarified who the ordering party is, and a possible target audience should also be identified. The next steps describe the process how to create a Narrative Environment in the context of a green roof.
The Outcome of the site analysis is a photo documentation with text or a Mood Board concerning the existing themes

4.1.2 Concept Development and Concept Formulation in CoNaNalysis

Creating a concept of a Narrative Environment for biodiverse green roofs

During the next two steps of the CoNaNalysis method, all these factors and information need to flow into the creative process of finding ideas, finally leading to a concept for Narrative Environment for biodiverse green roofs. These steps follow the process phases proposed by Jaeger (2010) and Mueller (2011) presented in 3.2.2 and are modified by the author to fit in the context of a biodiverse green roof to become part of the method CoNaNalysis. Table 21 to Table 22 with the details to those three steps can be found in the Annex A Figure 21 visualizes those steps: Concept development and Concept formulation.

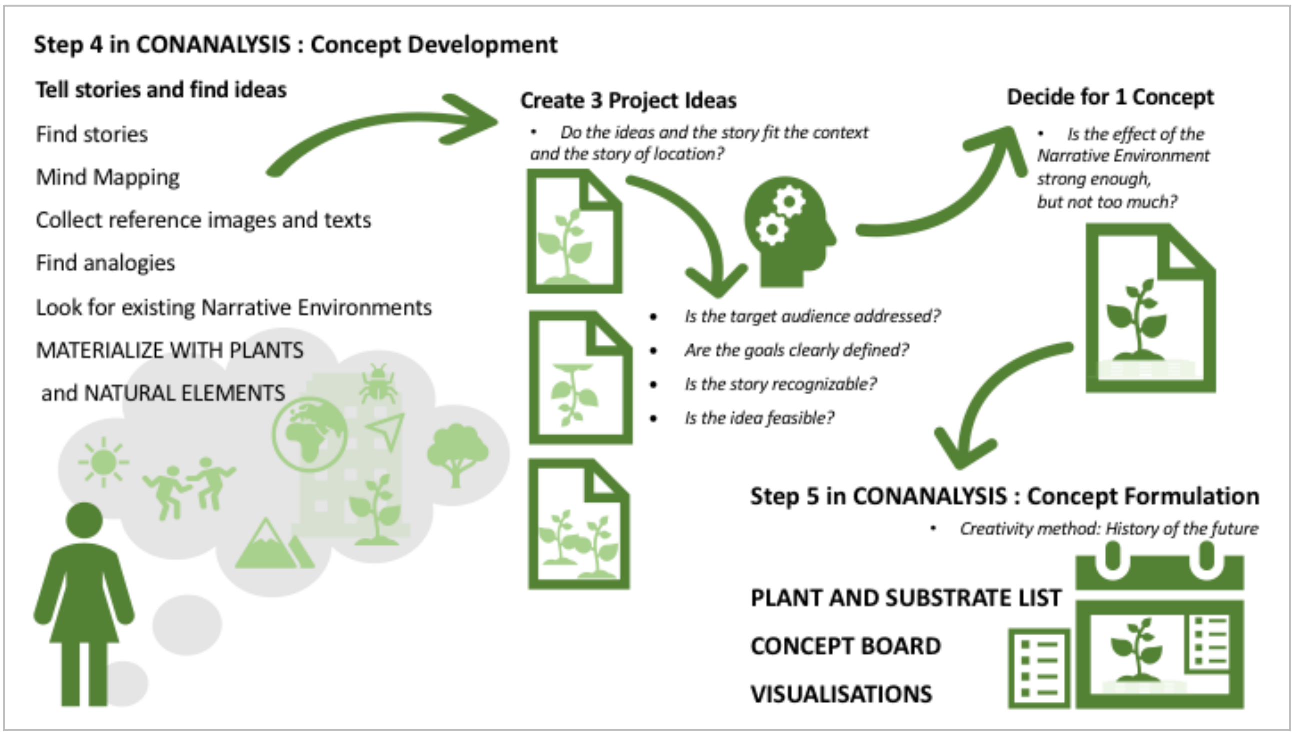


Figure 21: Visualization of Step 4 and Step 5: Concept Development and concept formulation in CoNaNalysis. Creation in Microsoft PowerPoint for Mac Version 16.17. L. Dierckx

Step 4 in CoNaNalysis: Concept Development: tell stories and find ideas

During the concept development, a story needs to be created using the elements of the site analysis. Jaeger (2010) recommends the use of creativity methods for finding stories and ideas for the Narrative Environment concept. Mind Mapping helps to create several project ideas. The details to the technique of Mind Mapping are explained in chapter 3. By conducting further research, collecting and analysing reference images and texts, by looking at existing Narrative Environments, and finding analogies, a story can be created. The critical question is: Do the ideas and the story fit the context and the story of location, so that identification is possible? Additionally, while creating the story, the materialization of the story into a Narrative Environment needs to be considered. Typical in the context of a biodiverse green roof is a materialization by use of natural elements, especially plants. This means that plants with dynamics in time and space will play a key role.

Indeed, the vegetation dynamics is the challenging factor for the Narrative Environment as its appearance develops and changes over time. The site analysis provides relevant information. Likewise, other natural elements such as logs, pine cones or rocks can also be incorporated into the Narrative Environment on the roof and help to increase biodiversity (see chapter 2). This materialization must be born in mind while creating the story. The outcome of this step is the formulation of three concept ideas. These three concepts are evaluated, asking the following questions:

- Is the target audience addressed?
- Are the goals clearly defined?
- Is the story recognizable?
- Is the idea feasible?

The three concepts are evaluated (rated) by the author in terms of:

- feasibility
- artistic & narrative potential
- comprehensibility by the audience (Table 21).

The concept idea that receives the highest rating will be further developed to a concept. The question, 'Is the effect of the Narrative Environment strong enough but not too much?' helps to ensure that the Narrative Environment responds to the site characteristics, that the Narrative Environment is well-integrated in the location and the target audience can strongly identify with the result (Figure 21).

Step 5 in CoNaNalysis: Concept Formulation

The last step of CoNaNalysis is the fine-tuning of the final concept to make it ready for realization on the green roof. Again, creativity methods can stimulate the creative process. In this step, the final formulation and preparation for realization are at the centre. The visioning method *History of the future* helps to create a mental picture of the result (see chapter 3). That way, a realistic view of the ideas and goals are drafted, and the specific measures and explicit materialization to get there become well-defined. It can be seen as a systematic review that evaluates the strengths and weaknesses of the concept and will help to the success of the Narrative Environment. The method is described in. All the details on the story and the materialization of the Narrative Environment are drawn up. The outcome will be visualized in a concept board, that aids to efficiently represent the concept with the main attributes in a visual way, accompanied by text explaining the ideas, location, materialization, and story. It enables to capture the essence of the concept in a quickly and efficient way. This method is experimentally tested, applied, and discussed in this paper through the following two case studies presented in the next section.

4.2 Case Studies in San Francisco and Basel

Two different case studies are presented in this chapter. By use of these case studies, the method CoNaNalysis a Narrative Environment on a biodiverse green roof can be experimented and tested on its practicability. Two basic concepts for biodiverse green roofs, each including a different Narrative Environment, are created by applying the steps of CoNaNalysis. Both case studies are situated in urban areas, as this is the context for this paper. Each location, however, has been chosen to experiment with a completely different starting position in terms of climate, socio-cultural-historical framework and ordering party. This enables first statements on its effectiveness. The first case study is the Meret Oppenheim high-rise roofs in Basel; the second is a rooftop on a residential building in San Francisco, California. Factors that could not be observed or measured are not recorded in this case study.

4.2.1 Case Study One: Concept Residential House San Francisco

Location

The living roof on this single-family building is in Rousseau Style is located at 185 Beaver Street at Corona Height Neighbourhood in San Francisco, California. (Figure 22 and Figure 23). It is located in the residential west side of the Castro District. This district is bordered by the Height Ashbury neighbourhood. It lies in the heart of downtown San Francisco, just blocks off of Market Street. The neighbourhood lies elevated above the city, providing splendid views over San Francisco. On the west side, it is close to a public park that continues east to the rock wall, above the nature sight of Corona Heights.

Figure 22 Location San Francisco. Image: Google Maps

Figure 23 The roof on 185 Beaver Street, San Francisco. Image: L. Dierckx

Case study facts

Location	185 Beaver Street, San Francisco, CA 94114
Coordinates	N 37° 45.9405' / W 122° 26.2243'

Elevation	87 MASL.
Year built	**1934** Historical Building, Family property
Property owner	Will Carpmill, +1 (408) 406 6774
Roof access	Private
Use	Rental residential apartment, 3 bedrooms
Rental price	$ 7000-8000 / Month (Upper class)
Dimensions of the roof	8 m x 14.85 m = 118.4 m2 / → ca 100 m2 = 1076.39 ft2
Orientation of the roof	East-West

Step 1 of CoNaNalysis: Off-site Analysis

Structure and Installation

Design load for the roof surface	20 PSF
Gradient of slope of the roof surface	The roof is for the most part flat, the upper east part of the roof has a little slope of 2%.
Year built, style	1934, Rousseau Style
Property owner	Will Carpmill, +1 (408) 406 6774,
Water requirements	Not available
Power supply requirements (for Lightning and equipment)	Not available
Roof access	Rung ladder
Lightning conductor on the roof	Not available
Safety facilities	Not available

Off Site Analysis: Abiotic factors: Climate, Temperatures, Precipitation, Precipitation, Wind, and Air Quality

The climate in San Francisco after Koeppen and Geiger is Csb (Mediterranean): it is typical to have wet and mild winters with lots of rain, also during spring and hot, dry summers (Keator & Middlebrook, 2007). Periods of drought in summer are also common. The yearly average temperature is 14.05°C. The hottest month is September (20.55°C), the coldest months are December to January (7.22°C) (U.S. Climate Data, n.d.) (Calflora, 2018). The average annual precipitation-rainfall in the Corona Height neighbourhood is 58 mm, with 68 days per year of precipitation. Most rainfall occurs from October until May. There is very little rain from June until October. There is no snowfall. Some neighbourhoods in San Francisco might have some frost during January, for the neighbourhood studies here, however, it is considered a rare plant hardiness zone: 10a and 10 b (Calflora, 2018). The growing season is ten months. In San Francisco, the wind blows mainly from the west coast. This wind brings cold air from the frigid California current in the morning and evening, it condensates while forming the fog that rolls in over the low range of hills of San Francisco. Often it dissolves during the warmer hours of the afternoon. San Francisco has no smog as the westerlies transport the pollution over the open landscape to the Sierra Nevada (The START Group, 2004).

Off Site Analysis: Abiotic factors: Topography, geology, hydrology, soil

Corona Heights lies elevated over the city. Streets are steep and hilly. The centre is its rocky outcrop, visible from many parts of the city, and offering an excellent 360-degree view over the city and the San Francisco Bay area. The natural area has steep bedrock slopes (San Francisco Recreation & Park, 2017). The underlaying bedrock of this area is Franciscan chert over Franciscan sandstone and greenstone, mostly covered by a thin layer of rocky soil. The local soil at Corona Heights is thin, sandy and rocky. Erosion from using the trails created runoff channels. The area has many gullies and further drainage happen by land overflow, building many small gullies with bare ground. Close to the site of this research, at the bottom of this natural area, at the base of the hill, there is a natural rock wall with a smooth, polished surface created by tectonic sliding (San Francisco Recreation & Park, 2017). The local soil is fine sandy loam with a Ph of 6.1, very slightly saline, and does not contain $CaCo_3$ (Calflora, 2018).

Off-Site Analysis: Framework conditions, Legal framework, ordering party, target audience

One or different permits from the Department of Building Inspection (DBI) are needed to install a green roof. The following code requirements apply to green roofs in San Francisco: the California Fire Code (2013), the California Building Code (2013), the California Plumbing Code (2013), the San Francisco Stormwater Ordinance and the San Francisco Planning Code. The San Francisco Administrative Code applies only for roofs larger than 1’000 square feet (San Francisco Planning Department, 2016).

Ordering party is a private property owner, Will Carpmill, who is an open minded and humorous US citizen in his mid-fifties, who used to work in the tech branch and is retired since longer. Since the house has always been family property, he is very attached to it. He values the surrounding area, with its views, wild nature and the geological formation (rock wall). He spends much time in nature and has developed an interest in native flora and fauna. Even if he will rent this location after it is remodelled, bringing biodiversity to his property and green roof is one of his main interests. One of his favourites non-native flowers is the Zinnia, which he would like to have integrated in the concept (see Figure 24). He likes pastel colours. He can image having a small deck where the occupants can relax and enjoy the view on the city and the green roof. The monthly rental price is approximately USD 8’000, to be in compliance with the local market. Thus, the target audience is high earning individuals or wealthy persons (1 or two parties). Further details can be found in the Questionnaire for Will Carpmill in Annex B

Figure 24: Zinnia sp. The property owners wish his favourite garden flowers integrated in the concept. Image: www.almanac.com/plant/zinnias

Off Site Analysis: Socio-cultural and historical context

San Francisco (SF) is characterized by its versatile, multicultural, and social openness. The dynamics of the SF culture and society is visible and perceptible in the different neighbourhoods and emanates outward to the rest of the world. San Francisco can be seen as an international hotspot of creativity and is considered as a trendsetting place. It attracts many tourists and it is a very visually appealing and diverse city, especially due to the mix of old and new buildings. Innovation and connectivity are being supported by technology (SF is the technology centre of the world for world leaders, here lies Silicon Valley) and art.

In the late 1800s, Corona Heights' brick material (chert and clay) was quarried, an activity that shaped the actual topography of the area with its sheer, exposed rock faces. Earlier names used for this hill were Rocky Mountain, Red Rock, and Rocky Hill. In 1940 the City of San Francisco bought the neighbourhood and renamed it Corona Heights. Today, there are tennis courts, playing fields, and the Randall Museum of Science, Nature and Arts (San Francisco Recreation & Park, 2017).

Step 2 of CoNaNalysis: On-site visit of the area

Two on-site inspections of the property, the roof, and the neighbourhood were performed on August 8, 2017 and on August 31, 2017.

On-site Analysis of the area: Biotic factors: Vegetation, quality of the surrounding area, diversity of structural elements, wildlife, wildlife connectivity.

On the west side, the property's backyard borders a small public recreational park with a play garden, which continues east to the rock wall. A trail leads to the natural area of Corona Heights (approximately 9.6 acres). 50% is covered by native grassland communities, 25 % hosts forests (especially in the periphery, both deciduous and coniferous trees), and 10% is scrub. The other 13% is a mosaic characterized by developed, bare ground or rock cropping at the top of the heights.

The present native plant communities are poison oak scrub, life oak forest and some extensive grassland communities, purple needlegrass prairie (California Prairie). The ecological value of the grassland communities is high; they host many drought tolerant flowers such as *Sidalcea sp*. (checkerbloom), *Eschscholzia californica* (California poppy), *Sanicula arctopoides* (footsteps of spring), *Iris douglasiana* (Douglas iris). Sensitive species that are present at Corona Heights are Deschampsia danthonioides (annual hairgrass), *Grindelia hirsutula var. maritima* (San Francisco gumplant), *Muilla maritima* (Muilla) and *Viola pedunculata* (Johnny-jump-up) the only hostplant for *Speyeria callippe callippe* (callippe silverspot butterfly). Some rare plant species offer foraging area for raptors and a habitat for many bird species and insects, for example, butterflies such as *Papilio zelicaon* (anise swallowtail). Also, some sensitive bird species appear at Corona Heights: *Hirundo rustica* (barn swallow) *Carduelis psaltria* (Lesser Goldfinch), *Sitta pygmaea* (pygmy Nuthatch) breed here. *Empidonax difficilis* (pacific-slope flycatcher), *Carpodacus purpureus* (purple finch) *Sitta canadensis* (red-breasted nuthatch) *Wilsonia pusilla* (Wilson's Warbler) are present. (San Francisco Recreation and Park Department, 2006; San Francisco Recreation & Park, 2017).

The author did not observe a high structural diversity nor any fauna. On the contrary, in the entire neighbourhood, many invasive plant species such as *Briza media* (quaking grass) and *Briza major*, *Centrantus ruber (*red valerian) different non-native *Sonchus* species *(*Sow thistle), *Genista monspessulana* (French broom) and *Avena sp.* (wild oat) were seen. These are a threat to the local vegetation and therefore downgrade the overall ecological value of the area. Due to the dry season, most of the vegetation did not look vital. The native succulent *Dudleya spathulifolium* (live forever) was detected on many rock formations in the area.

On the north face of the site, the property borders another residential building, separated by a narrow dark passage where only ferns and mosses were seen. In the surrounding streets, many little front yards are planted primarily with native and non-native succulents. In pavement cracks and curb sides, many non-native plants were observed.

The backyard with a wooden deck at the west face of the building borders the Corona Heights recreational park. There is a lot of shade due to the west-orientation and the adjacent big coniferous trees of the park. Since the building is being remodelled, the backyard has not been well maintained. The vegetation is a mix of spontaneous herbs, climbers, and some planted trees. A plant list and sketch of the vegetation in the backyard can be found in Annex C.

The natural area of Corona Heights offers inspiration to the author's plant choice for the concept. Since those plants only thrive on a very thin layer of soil, they can find a comparable water regime on the roof. Using similar plant communities enables a harmonic transition between the surrounding landscape on the ground and the green roof enhances its ecological and esthetical value. None of the plants on the backyard or the streets around the property can be used for the green roof concept; on the contrary, the green roof concept might inspire the property owner to landscape his backyard with native plants.

On-site analysis of the area: Social and cultural and historical context

In San Francisco, many megatrends become perceptible. Recognizable megatrends in this large city are Urbanization, Health, Neo ecology, Climate Change and Connectivity. These themes are all connected and often overlap. This element inspires the author for the storytelling aspect of the concept.

Observation occurred during the day. The author experienced this residential neighbourhood as being lively with little traffic. Adults and children visit the nature zone and play in the garden around Corona Heights. It is closely connected to the animated Castro District, with its many restaurants, bars, stores, and a farmer market.

Looking for natural materials in the area, that can be incorporated in the concept, the author found large pine cones and dead wood branches. The historical context of rock quarrying and brick production in Corona Heights in the 19th century inspired the author to use crushed brick in the concept.

Step 3 of CoNaNalysis: On-site inspection on the roof

The author met Will Carpmill, owner of the property who provide her orally a lot of background information about the location and the building. Most of the contents are covered in the Questionnaire (see Annex B).

A structural analysis was made by Eric Spletzer (Crafted Earth Inc.), who is a structural engineer and can go on-site to analyse the building in order to calculate the structural load of the existing roof: His findings concerning the load capacity confirm that the existing frame fails in deflection and does not meet the minimum requirement to support a vegetated roof outlined by the San Francisco Building Code. The roof framing needs to be upgraded to allow additional 131.82 kg/m2 (27 PSF) to meet those criteria. There are two options for the owner to upgrade the building:

- (a) Most likely, the building owner considers the construction of another story on top of that building. This allows to create a roof accommodating a load capacity of 300kg/m2 (60PSF).

- (b) The property owners can retrofit the building and upgrade the roof framing to enable 131.82 kg/m2 (27 PSF). Estimated costs are: USD 80’000.00 (Eric Spletzer, personal communication, August 8, 2017).

For this project, option (a) is considered more appropriate since the property owner will probably build another floor.

On-site inspection on the roof: Structure and Installation

Since no detailed architectural plans were available, the author measured the dimensions of the roof and drew a simple plan as a base for the green roof design. This plan has been edited in Vectorworks 2015. Additional information to the off-site research was collected. A small outlet for rainwater is available. The on-site visit on the roof shows that to build a green roof, the roof needs an upgrade to the safety facilities and lightning conductor to meet safety requirements.

On-site inspection on the roof: Local climate on the roof: Wind, Sun / Orientation und lightning conditions

The building at Beaver Street is sheltered from the prevailing westerlies by the hills of Corona Heights in the west. The tall coniferous trees behind the backyard at the west side of the building reinforce this effect. Due to the topography, at the left side of the rocky elevation, the site is sheltered from the fog. This creates a warmer and drier microclimate than areas in San Francisco that are fully exposed to the fog (Will Carpmill personal communication, August 8, 2017)

The building is east-west exposed. No bigger buildings or obstacles block the sunlight from the east and south-east sides. Thus, from spring to autumn, the entire roof is fully sun-exposed from early morning and throughout the entire day. In winter, the sun does not reach over the cliff south of the building (Will Carpmill personal communication, August 8, 2017). Cast shadows from the facing buildings appear only in wintertime.

On-site inspection on the roof: Visibility

The rooftop is visible from the adjacent privately-owned residential buildings in the neighbourhood. Furthermore, from several buildings further up Ashbury Hill, there is a view of the rooftop. A few steps south from the site, a steep hiking trail passes above, providing a clear view of the roof top. This trail is frequently used by people of all ages.

Creativity method: Mood Board

The Mood Board (see Figure 25) brings the first impressions and elements together.

Figure 25: Moodboard based on-site analysis of location, focusing on local native flora and fauna. Creation in PowerPoint Version 16.17. Images: L. Dierckx

Step 4 in CoNaNalysis: Concept Development: tell stories and find ideas

Idea finding: Individual Mind Mapping

This Mind Mapping started from the search for biodiversity-related ideas embedded in the socio-cultural context of San Francisco (see Figure 26). The author tried to explore ways on how to visualize and install it with plants and local materials on a green roof. The Mind Mapping is built on the findings of the site analysis and the long-term observations and experiences of the author during several stays in San Francisco over the past four years. The three main ideas are circled. The idea of climate change, the idea of different habitat types, and the idea of interference. These three ideas are elaborated to three concept drafts which are visualized with sketches in Table 12. Besides a visualization, an appropriate title is given. A brief explanation of the concept idea accompanies the sketches. How the audience can experience the concept on the green roof is clarified in the row 'how'. The target audience is defined as well.

Figure 26: Creativity method: Mind Map showing the ideas with word and sketches, the connections are marked with arrows. Sketch: L. Dierckx

The author collected looked at existing Narrative Environments to create a concept ideas.

Idea finding: Narrative Environment in the area

As part of the idea finding process, The author discovered the following Narrative Environments in San Francisco: 'Spire' in the Presidio Park from Andy Goldsworthy (see Figure 27), 'The Fog bridge' (see Figure 28) near the Exploratorium from GSL Landscape Architecture and whale bones on the California Academy of Sciences green roof (see Figure 29). She was fascinated how, by use of the local natural material at hand, a connection and identification to the environment could be established. This was yet another source of inspiration for the concept.

Further the author analysed reference images and texts, finding analogies (see Figure 30, Figure 31, Figure 32) leading to 3 concept ideas: Habitat garden, climate garden and Interference.

Figure 27: 'Spire' in the Presidio from Andy Goldsworthy. Image: c1.staticflickr.com/9/8505/8577627401_b52fdd2ed0_z.jpg

Figure 28: "The Fog bridge" near the Exploratorium from GSL Landscape Architecture. Image: www.flickr.com/photos/sooozhyq/32718172674/

Figure 29: Whale bones on the California Academy of Sciences green roof as design element to provide habitat diversity on the roof. Image: www.sarahgao.com/volunteering1/2017/7/19/california-academy-of-sciences

Idea finding: Reference images, analogies

Idea habitat garden

Figure 30: Inspiration for different plant habitat: different water availability creates different vegetation pattern. Mount Shasta Ares, North California. September 19, 2017. Image: L. Dierckx

Plant communities, 'classical garden' with different sections that are clearly separated.

Idea climate change

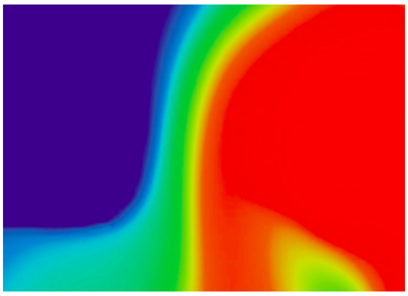


Figure 31 Image: Hot cold: classical colour for hot is red, cold is blue. possible style element to visualize climate change. Image: www.taschen.com/pages/en/catalogue/architecture/all/04636/facts.big_hot_to_cold_an_odyssey_of_architectural_adaptation.htm

Climate change, drought resistant plants, contrast hot and cold colours, glacier-desert, Ecology aesthetics: 'brown is the new green'.

Idea Interference

Figure 32: Pattern of interference analogies, inspiring the concept interference. Rain drops falling on the water surface of the Tyrrhenian See Italy June 20, 2018. Image: L. Dierckx

Interference in water, light, sound Waves of the Ocean Near San Francisco, Earthquakes that build a permanent threat in the Bay Area. Wind in Meadow, interference of different microclimates in the City

Idea finding: Materialisation with natural materials

Pine cones, dead wood and local crushed brick or rock found in the area, can be used as design element and create microclimates on the roof.

Figure 33: pine cones. Image: L. Dierckx

Figure 34: dead wood. Image: L. Dierckx

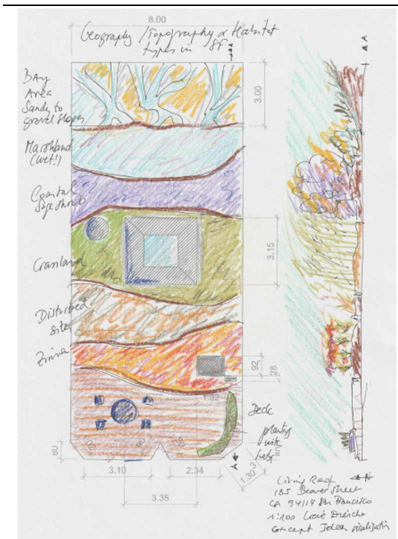
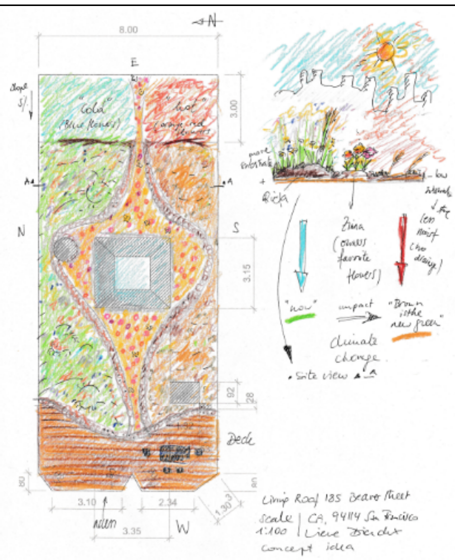
Figure 35: local crushed rock. Image: L. Dierckx

Idea finding: Materialisation with plants

The goal is to create a biodiverse green roof, therefore, drought resistant native plants and native plant communities that are adapted to the local conditions are used. Site analysis, research (Keator & Middlebrook, 2007) (Krummen et al., 2013) will help to find the appropriate vegetation and to create the final plant design. Since the property owner would like to have his favourite plant *Zinnia elegans* (common zinnia) grown on the roof, this is also included in the concept.

Idea finding: 3 Concept ideas

Table 12: 3 Concept ideas based on-site analysis and creativity methods: "Habitat Garden: a place to live", "Climate change garden" and "Interference" visualized and described. Drawings: L. Dierckx

Habitat Garden: a place to live in	Climate change garden: "before and after "	Interference
Visualisation		
		
Brief clarification		

Plant communities host plants that can live under the same circumstances. San Francisco and the Bay area hosts many native plant communities that can potentially be established on the roof. Arranging them next to each other from a dry habitat to a more humid one can provide an idea of the diversity of plants and the substrate they require. This might cause surprise to the audience, as they admire the native nature found.	The idea of Climate Change Garden is based on the idea that climate change has a large impact on biodiversity for flora and fauna. This narrative shows the 'before and after' of the vegetation simultaneously, whereby the transition is marked by the owner's favourite flowers. Will native plants have a chance on the roof in the future? Climate change is a megatrend impacting the world. Therefore, is a relevant topic in society, also in California, keeping in mind the serious droughts the state suffered in the past couple of years.	Green interference tells the story of the interaction of habitats and plant communities with each other, but also refers to the social aspect of interference of people, interacting and moving in the lively neighbourhood in and around Corona Height in San Francisco. The succession of plants makes this concept a dynamic, temporary, and endless event. Plants will organize themselves and share a habitat. The circles will disappear over time, leaving a self-sustaining living roof.
How		
Observe, experience, no action	Observe, experience by action: Use of the same plants for both areas, but in the 'after' area no watering, to 'mimic' extreme drought conditions. In the "before" area occasionally "hand watering".	Observe, experience by action: Watering the Z*innia elegans* flowers
Target Audience		
• Property owner • Tenants: wealthy people good to general education. • Neighbours that have insight on the roof. • Audience from the public hiking path above have insight on the roof.	• Property owner • Tenants: wealthy people good general education. • Neighbours that have insight on the roof. • Audience from the public hiking path above have insight on the roof.	• Property owner • Tenants: wealthy people good to general education. • Neighbours that have insight on the roof. • Audience from the public hiking path above have insight on the roof.

Idea finding: Evaluation and rating

Table 13 shows the evaluation of the three concept ideas with their three evaluation criteria.

Table 13: Criteria to evaluate the concepts. Feasibility, artistic potential, and estimated comprehensibility by the audience. Rating: + = low ++ = middle, +++ high. Based on the rating Concept idea 'Interference' is the ‚winner '.

Habitat Garden	Climate Change Garden	Interference
Is the idea feasible?		
The use of different substrates and plant communities is possible. Inclusion of natural material is possible. Eventually high maintenance is needed to keep the plant sections separate.	Hard to predict development of vegetation for both sides, which might make it difficult to visualize the idea of climate change without additional explanation.	Leaves lots of options to combine plant and natural material to create the different circles. Easy to implement once final concept is created. No maintenance needed, as self-sustaining plant system is the scope.
++	+	+++
Are the goals clearly defined?		
Bring San Francisco's biodiversity to the audience.	Reflects about the impact of climate change.	Show interaction of nature in its dynamic and temporary aspects with different native plant communities, similar dynamic and interaction processes in San Francisco society.
+++	++	+++
Is the target audience addressed?		
Similarly, a classical garden a broad audience can be reached, not very specific.	Even if the idea of climate change is not understood, the target audience can enjoy an appealing design.	The well-educated audience that live at the 'pulse' of the city, might be able to experience and understand the Narrative. People who have insight on the roof can enjoy the appealing design.
+	+	++
Is the story recognizable? **Do the idea and the story fit the context and the story of location, so that identification is possible?**		
Easy to 'visually' understand as straight forwards separation of areas. This type of garden is known on the ground, so identification can happen.	Due to the several droughts in the past years, the target audience might be able to capture it. Easy to 'visually understand' as straight forwards separation of areas.	The idea of interference is omnipresent in and around San Francisco. Therefore, connection and identification to the concept can be easily realized and understood,

+	+++	when the audience is willing to 'listen' to the installation. +++
Total Rating / Comments / Arguments		
+++++++ (7) This idea refers to the classical garden, where sections are clearly separated, this is very static and does not reflect the dynamic of SF and development of the plants. It is too educational, too bipolar and too two-dimensional. There is little room for chaos and change, in addition, high maintenance might be required to maintain the different sections clearly separated.	+++++++ (7) This concept is too bipolar, too two-dimensional. It is too educational and therefore not fitting to the requirement of the owner and user of the green roof. There is little room for natural vegetation dynamic. There is a chance that the vegetation on both sides develop similar, so the impact of climate change cannot be understood. Might require regular weeding to keep the areas clearly separated.	+++++++++++ (11) This concept is most site-specific in terms of reflecting the social and cultural dynamics of San Francisco. Therefore, the space gets an identity-forming function that is typical for the city. Hence, it enables identification with San Francisco as location. By use of native vegetation where the dynamic development on the roof is desired, the audience finds its identity and can connect to it.

Table 13 shows that the concept idea of Interference will be further elaborated to the final concept. The question, 'Is the effect of the Narrative Environment strong enough but not too much?' for this concept can be answered with a "yes" since it harmoniously integrates the vegetation and materials found in the area. Even if the story is not understood, an esthetical design for a biodiverse roof is formed.

Step 5 in CoNaNalysis: Concept Formulation

Creativity method: History of future

To further test the feasibility of the concept, the creativity technique *History of the future* (see chapter 3) is used. The result is shown in Annex D.

Concept idea and concept board

The theme and main goal of the concept 'Interference' is to create a biodiverse green roof that promotes native flora and fauna and commits to a more biodiverse city. The narrative approach of the concept tells a story of the dynamic and interaction of habitats and plant communities with each other, but also refers to the social aspect of interference of people, interacting and moving in the lively neighbourhood in and around Corona Heights in San Francisco. The succession of plants could make this concept a dynamic, temporary, and endless event. Plants can organize themselves and share habitats.

The concept aims to provide a high aesthetic value that considers ecological principles by use of natural substrate, native plants and natural local elements that help create diverse microclimates. At the same time, it also meets the more practical needs of the owner. The owner wishes a little wooden deck to relax and enjoy nature on the roof and the view over the city.

Figure 36: Concept Board Narrative Environment for biodiverse green roof in San Francisco. Design: L. Dierckx

Basic concept

The idea of interference will be implemented by vegetation and substrate and made perceptible as a Narrative Environment on the green roof as follows. Different circular wave groups expand in all directions (see Figure 37). A wave group consists of waves with different sizes originated from the same centre. For each wave group another native plant community is chosen. This requires different substrate composition and substrate depth (e.g. 8 to 20 cm). That way, with overlapping epicentral circles, the different vegetation areas are created and made visible. In the interference knots (zones), the different plant communities will meet. Analogue to the intersections of waves that are formed by transport of energy, there could be a mixing of plants communities caused by their natural dynamic.

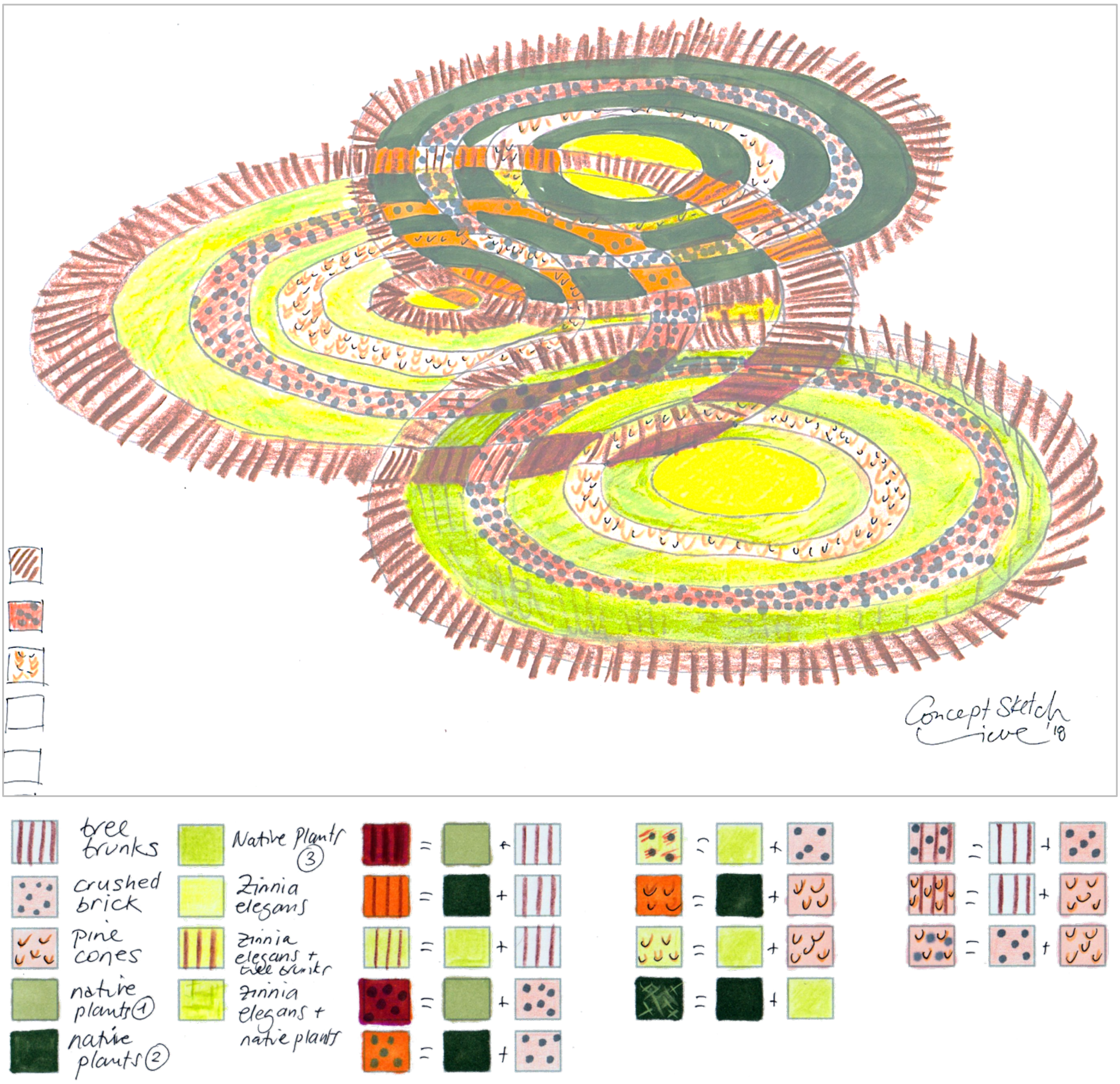


Figure 37: Visualization Interference with different plant communities and different natural materials. Overlap in the knots. Concept sketch: L. Dierckx

In order to visualize the concept of interference clearly, in the gaps (circles) between the single circles there will be no planting. This enables in the beginning a clear separation of the different circles. The gaps will be filled with different natural elements from local sources in order to create additional different microclimates that encourage biodiversity. Materials are tree trunks and dry limbs, crushed brick and pine cones.

If no maintenance in terms of weeding and new seeding is performed, over time the wave structure with the intersection knots will dissolve, analogue to how waves dissolve if no new energy is supplied. This means that the waves will break up due to natural succession, the exposed substrate surfaces will overgrow and the vegetation and intersections flow into each other or disappear gradually. The result could be a full coverage on the roof of a self-sustaining vegetation, caused by a its own self-supporting dynamic momentum and developing according to the natural succession.

The concept of interference continues when the positive effect of a single green roofs in the city circular spread like waves from one green roof to the next and their impact start overlapping. The higher the density of the green roofs installed, the stronger the “green” interference in terms of connecting habitat for certain species between green ground site and other green roofs in dense cities (Braaker et al., 2014). Every green roof counts. Thus, the ecological potential of a city can be reinforced and encouraged (positive interference). Such as (as with) a downpour on a water surface there are many fields of activity that mesh together. The result is a living space for native flora and fauna, in a dense urban area. The deck enables the owner to get emotionally involved in this nature-like landscape. Since it is visible by the neighbours and from a public hike, the idea can be spread and shared.

Figure 38: Visualization of the effect of Interference: connecting habitat between ground sites and other green roofs. Sketch: L. Dierckx

The plant list (see Table 23)and substrate list can be found in Annex E

4.2.2 Case study Two: Concept Meret Oppenheim Building in Basel

Location

The Meret Oppenheim (Figure 40) high-rise is located near the SBB Railway station(see Figure 41) in the city centre of Basel. The city of Basel is a small city (approximately 200,000 inhabitants) situated in north of Switzerland at the 'bend in the Rhine' (see Figure 39 and Figure 42) near the border of France and Germany. The city has beside a lot of historic buildings plenty of important modern architecture. Basel is one of the leading cities for art and culture worldwide (for example Art Basel). Many international research and pharmaceutical and chemical companies are located here, which gives Basel an international character. The city of Basel has a long history in building green roofs (SBB, 2018). Supported by financial incentives programs and building regulations back in the nineties, in 2003 Basel did have the largest number of green roofs in Europe (Climate ADAPT, n.d.).

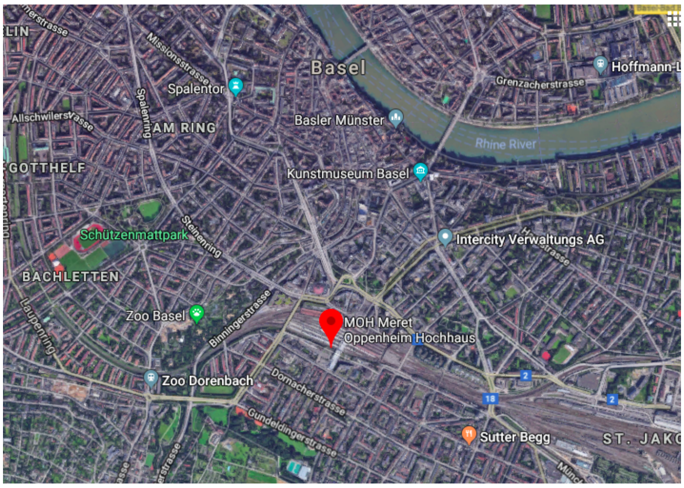


Figure 39: Location of the Meret Oppenheim high-rise near the SBB Railway Station on Basel. Image: Google maps

Figure 40: Visualization Image Meret Oppenheim High-rise Image: moh-basel.ch

Figure 41: Visualization Meret Oppenheim square with fountain and sculpture to honour Meret Oppenheim. Image: moh-basel.ch

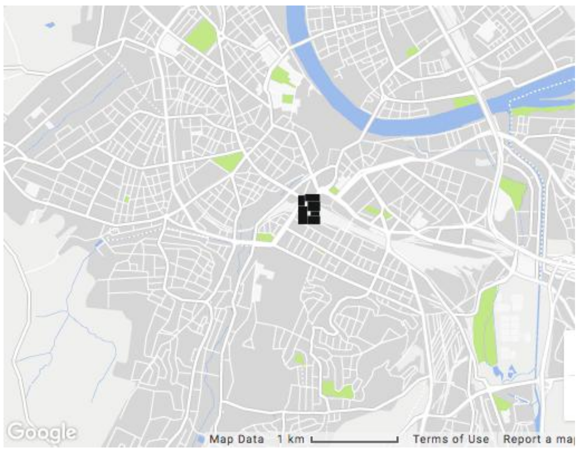


Figure 42: Location of the Meret Oppenheim High-rise 1,2 km away from the Rhine-river. Image: moh-basel.ch/en/

Case study facts based on (Herzog & de Meuron Basel Ltd., 2018)

Location	Meret Oppenheim-Square 4053 Basel
Coordinates	611088.49 / 266230.80 47° 32′ 45.9″ N, 7° 35′ 13.8″ E
Typology	High-Rise Building with 25 above ground floors
Elevation	Approximately 289 MAS
Year built	2016 under construction - ready for occupancy as of spring 2019
Property owner	SBB real estate
Architects	Herzog & de Meuron
Landscape Architects	Westpol Landscape Architects
Use of the building	Mixed Use Development Ground Floor: Office space, café and restaurant (Tibits), entrances housing Level 1 to 5: Office space (e g Swiss Radio and Television SRF) and service areas Level 6 to 24: Housing, 153 apartments (1.5 to 5.5 rooms including 2 penthouses)
Dimensions of the roof	Different dimensions
Building Data	Site Area: 31'754sqft / 2'950sqm Gross Floor Area (GFA): 325'985sqft / 30'285sqm Number of levels: 25 Footprint: 25'941sqft / 2'410sqm Building Dimensions: Length 167ft / 51m; Width 144ft / 44m; Height 85m
Orientation of the roof	South, South West, North West

Step 1 of CoNaNalysis: Off-site research

Structure and Installation

Design load for the roof surface	300 kg / m^2
Gradient of slope of the roof surface	< 2%
Water requirements	No data
Power Supply requirements (for Lightning and equipment)	No data
Roof access	Stair cases
Lightning conductor on the roof	yes
Safety facilities	yes

Off Site: Abiotic factors: Climate, Temperatures, Precipitation, Wind, Air Quality

The location has an oceanic cfb (de.climate-data, 2017) climate with four seasons, and can be characterized as dry and warm. It is one on the driest areas north of the Alps. This mild climate is caused by the geographical position of the swamp of the Oberrheinischen Lowland plain. The yearly average temperature of 9.2 °C. July is the warmest month, winter are mostly frost free (January average 0.7 °C average), yearly precipitation is 778 mm/year, divided over the whole year with peaks in the summer months. The prevalent west wind blows moist air from the Atlantic, the North Sea and the Mediterranean Sea. Due to the ongoing global warming, it is assumed that the Mediterranean climate tends to converge. Average rainfall decreases in the summer, hot periods and heat waves increase in the summer. Likewise, cold winter days and nights decrease (MeteoSwiss, 2011). This is particularly noticeable in a city, where ventilation often lacks. Another challenge is the nitrogen load, which is increased in cities, causing difficulties to the urban vegetation, since they lack the possibility of nitrogen buffering (D. Jaenneret, personal communication, November 28, 2016).

Local climate on the roof: Wind, sun / orientation und lightning conditions

The high-rise Meret Oppenheim has 6 roofs for biodiverse green roofs. Additionally, at the northwest -side of the building, there is a covered bicycle shelter that will be greened as well. Site specification on orientation, elevation and climate conditions are shown on Table 14.

Table 14: Site specification of the planned green roofs at the Meret Oppenheim high-rise.

Floor / Use	orientation	Site characteristics	Elevation (rounded to 0,5)
5th floor / office space	Southwest	Sunny location, dry, windy, Some areas semi-shade and dry Mainly at noon and in the evening very sunny	17 m
6th floor apartments	South-West	Sunny location, dry, windy Some areas semi-shade and dry. Mainly at noon and in the evening very sunny	24,5
15th floor apartments	South	High altitude Sunny and dry, very wind exposed	52 m
24th floor apartments	South	High altitude Sunny and dry, very wind exposed	79 m
25th floor technical roof	South	High altitude and dry, very wind expose	82 m
1st floor: area all around the building	All directions	Sunny, semi-shade and shade	5.5 m
1st covered bicycle shelter	North- West	Sunny, semi-shade and shade	n.d.

Off Site analysis: Abiotic factors: Topography, geology, hydrology, Soil

The site is approximately 2 km away from the Rhein. Soil samples showed that the original upper 70 cm upper layer at the site consist of gravel, sand, silt (grey brown to brown), earth moist, with stones, with little fragments of tiles (Kanton Basel-stadt, 2013)

Off-Site analysis: Framework conditions, Legal framework, ordering party, target audience

The Meret Oppenheim high-rise consists of a six-story pedestal with service areas and a high-rise building with apartments on 19 floors. To be in line with the Basel's Building and Construction Law, all flat roof space on this new building that is not used for other purposes, need to be greened following their guidelines.

> *"Basel's Biodiversity Strategy for Green Roofs Findings from this research have led to an amendment in the building and construction laws in Basel. Swiss land-use regulations stipulate that interference with the natural environment be kept to a minimum, and that soil be used in a sustainable way. Federal legislation on the conservation of nature and cultural heritage requires that endangered species be appropriately protected. In accordance with these regulations, the canton of Basel mandates the design and use of substrates for extensive green roofs as part of its current biodiversity strategy. In general, green roofs must be constructed on all new buildings with flat roofs (Nature and Landscape Conservation Act § 9; Building and Planning Act § 72). On roofs of over 500 square meters, the substrates must be composed of appropriate natural soils from the surrounding region and must be of varying depths"* (Brenneisen, 2006, S. 29).

The Federal Act on the Protection of Nature and Cultural Heritage (NCHA) requires that the executing authorities' cantons (federal states) and municipalities provide ecological compensation (NHG Art. 18). Ecological compensations measurements aim to conserve and restore habitat and habitat connectivity, mainly in urbanized landscapes. Other goals are the promotion of indigenous biodiversity and to protect endangered plant and animal species within the framework of laws and planning (Green Infrastructure Consultancy, 2017). Therefore, it is required to use regional natural soil substrates as some endangered species need to be protected may have specific adaptations to the native soil.

This builds the base for the SIA 312 Quality Standard 'green roofs' that includes, amongst other green roof quality standards, ecological parameters in order to achieve well improve biodiversity. Even if these norms are not a law, they are commonly applied in Switzerland to ensure a high-quality standard.

Minimum standards are:

- Substrate depth: min 100 mm (loose fill)
- Total Water retention capacity (percolating water capacity plus Volume plant available water min. 45l/m2
- Plant available water is min 22,5 l/m2.
- Seeds from Swiss Ecotypes, site appropriate.

Since the total flat roof surface of this building is over 500 square meters, the cantonal Nature and Landscape Conservation Act § 9; and the Building and Planning Act § 72 apply. They can be seen as the ordering party for this project. The building owner is SBB real estate.

Considering the high-end standard of the apartments (SBB, 2018) the tenants of the private apartments that will have a view on the green roofs, the target audience are wealthy people. The apartment size varies from 1,5 to 4,5 room apartments and includes three penthouses. This means that singles, couples or families could live here. Due to the international character of the city of Basel and its location in direct proximity to the SBB railway station, this building might not only attract local individuals, but also appeal to an international public. That means that for those people the connection to the area might fail. However, the green roof might help connect newcomers to the beauty of the local Swiss nature. Further target audiences are individuals that have insight on part of the first-floor roof.

Off Site analysis: Socio-cultural and historical context.

The high-rise will be built to honour the Swiss artist and lyricist Merett Openheim (1913-1985). She was closely connected to Basel during her life. Meret Oppenheim also died her. Meret Oppenheim had a close connection to nature and spent many years in Basel; she had an atelier at her grandmother's house while she studied at the School of Design in Basel. She met her husband and when she moved to Bern, she would always return to Basel to celebrate Fastnacht (SRF Schweizer Radio und Fernsehen, 2013).

Step 2 of CoNaNalysis: On-site visit of the area

Two on-site inspections of the neighbourhood were performed. The first took place on June 30, 2017, On the same day, the author participated in a meeting with Westpol Landscape architects in Basel to clarify the project details. The second visit was on May 25, 2018. meeting was set up with all parties involved to clarify the last steps before implementation. On both meetings, the author received relevant information that was implemented into the project.

On-site analysis of the area: Biotic factors: Vegetation, quality of the surrounding area, diversity of structural elements, wildlife, wildlife connectivity.

In this urbanized neighbourhood, there is not a bigger green space in the direct area around the site. The closest bigger public green space is the Basler Zoo, approximately 0.5 km east of the Meret Oppenheim building and the Margretenpark, 0.5 km south. Figure 43 to Figure 46 show different typologies of green space in the area around the neighbourhood.

Figure 43: Green roof with native and non-native invasive species south of the SBB passerelle near the Meret Oppenheim High-rise. Image: L. Dierckx

Figure 44: Public green space with spontaneous vegetation south of the SBB passerelle near the Meret Oppenheim L. Dierckx

Figure 45: Green wall near Gueterstrasse provides habitat and food source for birds and invertebrates. Image: L. Dierckx

Figure 46: The native plant Echium vulgare in a front yard near the Meret Oppenheim high-rise attracts many pollinators. Image: L. Dierckx

The streets around the neighbourhood have a few plantings of native and non-native trees(see Figure 47): 17-year old *Carpinus betulus* 'French Fontaine' at the Gueterstrasse (see Figure 48), *Acer platanoides* (tree-group of nine trees) south-east of the railway bridge, two 26 years old *Tilia cordata 'Green Spire'* and at the Gempenstrasse two *Aesculus flavus* can be found.

Figure 47: There are little trees in the area around the Meret Oppenheim high-rise. Source: map.geo.bs.ch

Figure 48: 17-year old Carpinus betulus *'French Fontaine' at the Gueterstrasse Image L. Dierckx*

In the very densely built Gundeldinger neighbourhood, public and private green spaces are limited. To increase the life-quality in this district, the government council developed the legislation plan 2013-2017 to create a green and open space concept (in the context of urban development Basel South / Gundeli Plus). Indeed, the ecological quality of this is low, although this neighbourhood has many backyards and front gardens of which many are sealed, or lack of diversity. The association 'Ökostadt Basel' launched a project in 2015 that will run until 2018 for upgrading in terms of unsealing and replanting front gardens and courtyards, to contribute to enhance the nature conservation in the city. Also, the green and open space concept Gundeldingen lists 58 measures to enhance the quality of life in the Gundeldinger neighbourhood. One of the four strategic emphasis focus on the design of public green space to enhance attractiveness (Stadtgaertnerei Basel).

At the time this thesis is written, the site is still under construction and not accessible. Online- Visualizations show that the Meret Oppenheim square will be planted with native and non-native trees (SBB, 2016), native wild hedges, as well as some facade greening (see Figure 49)

Figure 49: Visualization of the future green space around the Meret Oppenheim high-rise. Visualization: moh-basel.ch/wp-content/uploads/sites/25/panoramatour/

On-site analysis of the area: Social and cultural context

The neighbourhood seems very lively and highly frequented during the day, with a lot of pedestrian and bikers on the way to and from the railway station or the tramway. There is a social mix and different nationalities make the street scene look dynamic. There are bigger and smaller local stores, combined with restaurants and apartments, often with front and backyards.

Step 3 of CoNaNalysis: On-site inspection on the roof

Since the building was under construction during the time this Bachelor thesis was written, no on-site visits could be made. Nevertheless, the author has visited many natural green roofs in Basel, which gives her an idea about the situation on the roof. However, she has never visited a high-rise green roof with 25 floors.

On-site analysis on the roof: Visibility

The roofs are all visible from an airplane. All the roofs are visible from their respective apartments and offices as well as from the neighbor apartments / offices above and at the side.

Mood Board (see Figure 50)

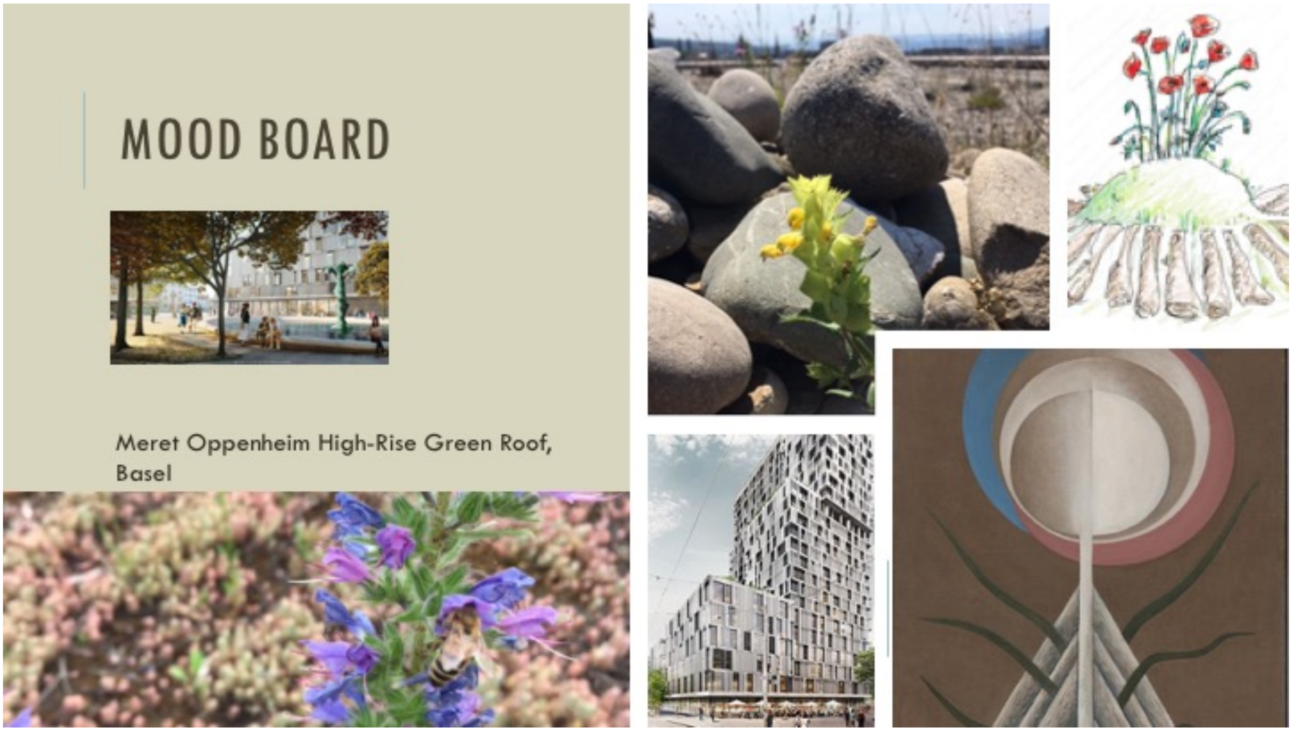


Figure 50: Moodboard based on the site analysis: Inspiration: Honour to Meret Oppenheim focusing on local native flora and fauna. Creation in Microsoft PowerPoint for Mac Version 16.17. Images: L. Dierckx

Step 4 in CoNaNalysis Concept Development: tell stories and find ideas

Idea finding process / individual Mind Mapping

This Mind Mapping started from the search for biodiversity related ideas embedded in the socio-cultural context of Basel. As per Figure 51, three main ideas are underlined in red: Hommage at Meret Oppenheim, Artwork, Interpretation, and Eyecatcher.

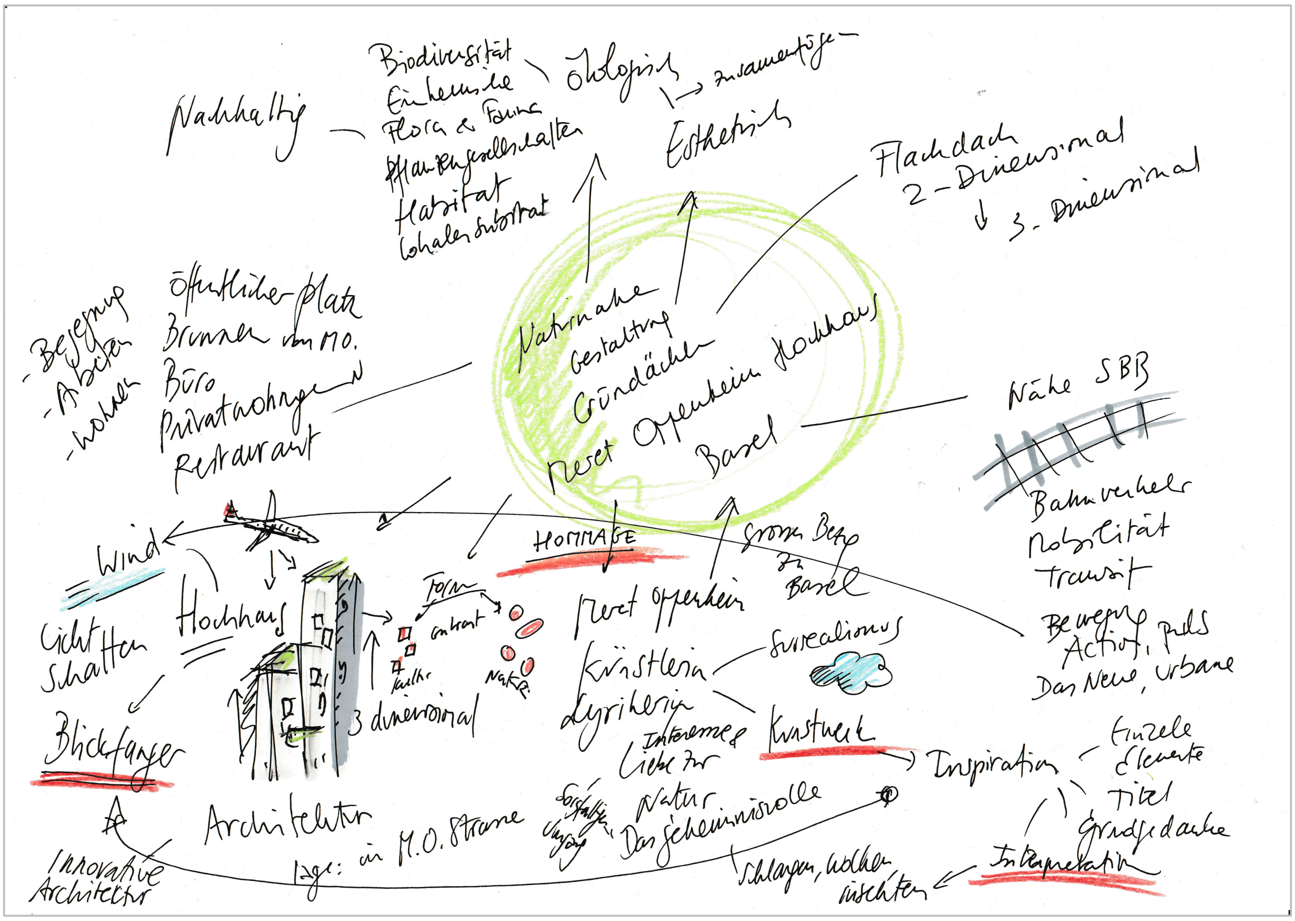


Figure 51: creativity method: mind map showing the ideas with word and sketches, the connections are marked with arrows. Image: L. Dierckx

The author collected and analysed reference images (see Figure 53 to Figure 55), finding analogies and looked at existing Narrative Environments in the city of Basel (see Figure 56 and Figure 57) to create a the Narrative Environment story.

The three concept ideas are based on the same inspiration: to bring a homage to Meret Oppenheim. This high-rise will be located at the Meret Oppenheim-Strasse and the Meret Oppenheim-Platz. To honour her, this street, the square and the building are named after her (see Figure 52). Furthermore, a round fountain with 19 meters in diameter will be installed, around which people can sit. A reproduction of the sculpture

"Spiral (the course of nature)", which Meret Oppenheim made as a model in 1976, will be reminiscent of the artist associated with Basel (SBB, 2016). Continuing this train of thought to honour her consistently leads to the starting position of these concept ideas.

Figure 52: Artwork of Meret Oppenheim as direct inspiration, homage. Image: (SBB, 2016)

Reference image "Blume auf Huegel" a painting from Meret Oppenheim (see Figure 54) generated two concept ideas.

Idea finding: Reference images, analogies

Idea		
Homage Meret Oppenheim	Homage Meret Oppenheim	Homage Meret Oppenheim

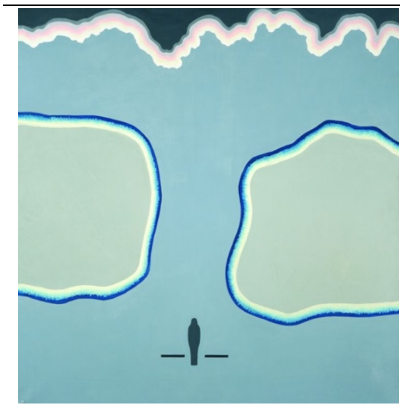



Figure 53: La condition humaine (Da stehen wir) 1973. seek.rs/image/87632/pmeret-oppenheim-emla-condition-humaineem-emda-stehen	*Figure 54: Blume auf Huegel (Flower on a Hill), (Oppenheim, M. (1964)., Hannover Sprengler Museum. Image: www.flickr.com/photos/mazanto/21330309422*	*Figure 55: Blume auf Huegel (Flower on a Hill), (Oppenheim, M. (1964)., Hannover Sprengler Museum. Image: www.flickr.com/photos/mazanto/21330309422*
Analogies		
Cells, clouds, sea, coast and islands	human being, hill, roots, soil, insect	human being, hill, roots, soil, insect

Idea finding: Narrative Environment in the city of Basel

Figure 56: Eyecatcher circle of dead wood logs increase: biodiversity on the green roof of the Main Exhibition Hall 1 in Basel. Image: greenroof.com

Figure 57: Papaver rhoeas (common poppy) on a green roof in Basel. May 22, 2017.l Image L Dierckx

Idea finding: Materialization with natural materials

Dead wood and riverbed rocks can be used to design biodiverse green roof (see Figure 58 and Figure 59).

Figure 58: Creating microhabitat with dead wood on a green roof in. Basel, June 12, 2017 Image: L. Dierckx

Figure 59: Creating microhabitat with riverbed rocks on a green roof in Zurich 13, 2017. Image: L. Dierckx

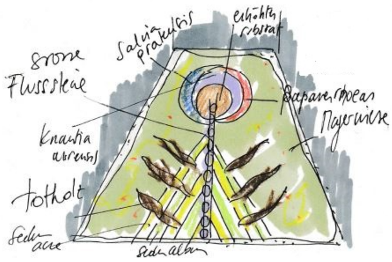
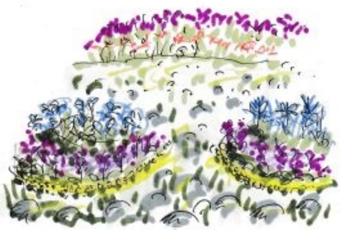
Idea finding: Materialization with plants

The goal is to create a biodiverse green roof. Therefore, native plant communities that are adapted to the local conditions are used. Site analysis, research and earlier studies on plants will help to find the appropriate vegetation and to create the final plant design. Since there are many green roofs with different conditions on this building, different habitat can be created, depending on the orientation, elevation and substrate used.

Idea finding: 3 concept ideas

In all three concept ideas, the idea of the 'homage' is pursued. Here artwork serves as an inspiration for the design of these biodiverse green roofs (see Table 15). The author looked for Artwork that could be interpreted in a three-dimensional situation.

Table 15: Visualizations of the three concept ideas/ Sketches: L. Dierckx

La condition humaine (da stehen wir), 1973	Blume auf Hügel (1964)(1)	Blume auf Hügel (1964)(2)
Visualisation		
		
		
Brief clarification		
The oil painting “La condition humaine” (da stehen wir), 1973. The observer stands outside (roof terrace or airplane) the biodiverse green roof but looks into the newly created world of nature on the roof and can thus participate in it. Different areas are separated from each other and present different areas of life or plant communities. The room layout on the picture is taken over in the horizontal roof level. Thanks to different substrate	The oil painting, “Flower on Hill”, from 1964 shows Meret Oppenheim’s great relationship with nature. The picture serves as inspiration for all extensive rooftops to be greened. However, each roof will receive its own individual appearance, since it works with other substrates, materials and different vegetation combinations. It benefits the ecological dimension by creating a variety of micro-climates. From a bird's-eye view, the ‘expert’ might recognize Meret Oppenheim’s	The oil painting, “Flower on Hill”, from 1964 shows Meret Oppenheim’s great relationship with nature. The picture serves as inspiration for on all extensive rooftops to be greened. However, each roof will receive its own individual appearance, since it works with other substrates, materials and different vegetation combinations. It benefits the ecological dimension by creating a variety of micro-climates. From a bird's-eye view, the ‘expert’ might recognize Meret Oppenheim’s

heights and plant mixtures, the shapes stand out from each other.	painting in its different 'green' interpretations. The room disposition on the roof reflects the different elements in the painting. Depending on the dimensions of each different roof, it will be interpreted differently.	painting in its different 'green' interpretations. The idea 'Flower on Hill' is taken literally. It builds the centre of the design. The two-dimensional painting becomes the inspiration for a three-dimensional landscape.
How		
Observe	Observe	Observe
Target Audience		

- Tenants: wealthy people, good to general education, Swiss and foreign nationals.
- Neighbours that have insight on the roof.
- Audience from individuals, flying over Basel (Flight route). Green roofs can be partially seen by the public from the SBB bridge.

Idea finding: Evaluation and rating

Table 16 shows the evaluation of the three concepts with its three evaluation criteria.

Table 16: criteria to evaluate the concepts. Feasibility, artistic potential, and estimated comprehensibility by the audience. Rating: + = low ++ = middle, +++ high. Based on the rating concept idea 'Blume auf Hügel (2) e' is the ‚winner '.

La condition humaine (da stehen wir)	Blume auf Hügel (Flower on a hill) (1)	Blume auf Hügel (Flower on a hill) (2)
Is the idea feasible?		
This concept idea leaves lots of options to combine plant and natural material, but might require high maintenance to keep the different sections separated. The installation can be done in line with local regulations. Due to the irregular roof shape, not all green roofs on the building qualify to present this design.	This concept idea leaves lots of options to combine plant and natural material, but might require high maintenance to keep the different sections separated. The installation can be done in line with local regulations. Due to the irregular roof shape, not all green roofs on the building qualify to present this design.	This concept idea leaves a lot of options to combine plant and natural material to create the different flower hills, including different material to emphasis the graphic structure of the hill. The visual image of the hill can still be effective with low maintenance. The installation can be applied in different variations, depending on the size and shape of the roofs.
+	+	+++
Are the goals clearly defined?		
Honour to Meret Oppenheim Create biodiverse green roof	Honour to Meret Oppenheim Create biodiverse green roof	Honour to Meret Oppenheim Create biodiverse green roof

+++	+++	+++
Is the target audience addressed?		
Yes, the apartment tenants and office employees can enjoy the esthetical look on of the setting. +++	Yes, the apartment tenants and office employees can enjoy the esthetical look on of the setting. +++	Yes, the apartment tenants and office employees can enjoy the esthetical look on of the setting. +++
Is the story recognizable? **Do the idea and the story fit the context and the story of location, so that identification is possible?**		
It suits to the local regulations and artistical cultural context of the building and the site 'Meret Oppenheim'. +++	It suits to the local regulations and artistical cultural context of the building and the site 'Meret Oppenheim'. +++	It suits to the local regulations and artistical cultural context of the building and the site 'Meret Oppenheim'. +++
Total Rating / Comments / Arguments		
++++++++++ (10) This idea needs a lot of maintenance to keep the design. This is in contradiction to the requirements of a biodiverse green roof.	++++++++++ (10) This idea needs a lot of maintenance to keep the design. This is in contradiction to the requirements of a biodiverse green roof.	++++++++++++ (12) The Narrative Environment remains observable even with low maintenance and therefore a good match of art and biodiversity.

The rating in Table 16 shows that the concept idea of interference will be further elaborated to the final concept. The question, 'Is the effect of the Narrative Environment strong enough but not too much?' for this concept can be answered with a "yes" since it harmoniously integrates the vegetation and materials found in the area. Even if the story is not understood by all individuals, an esthetical design for a biodiverse roof is formed.

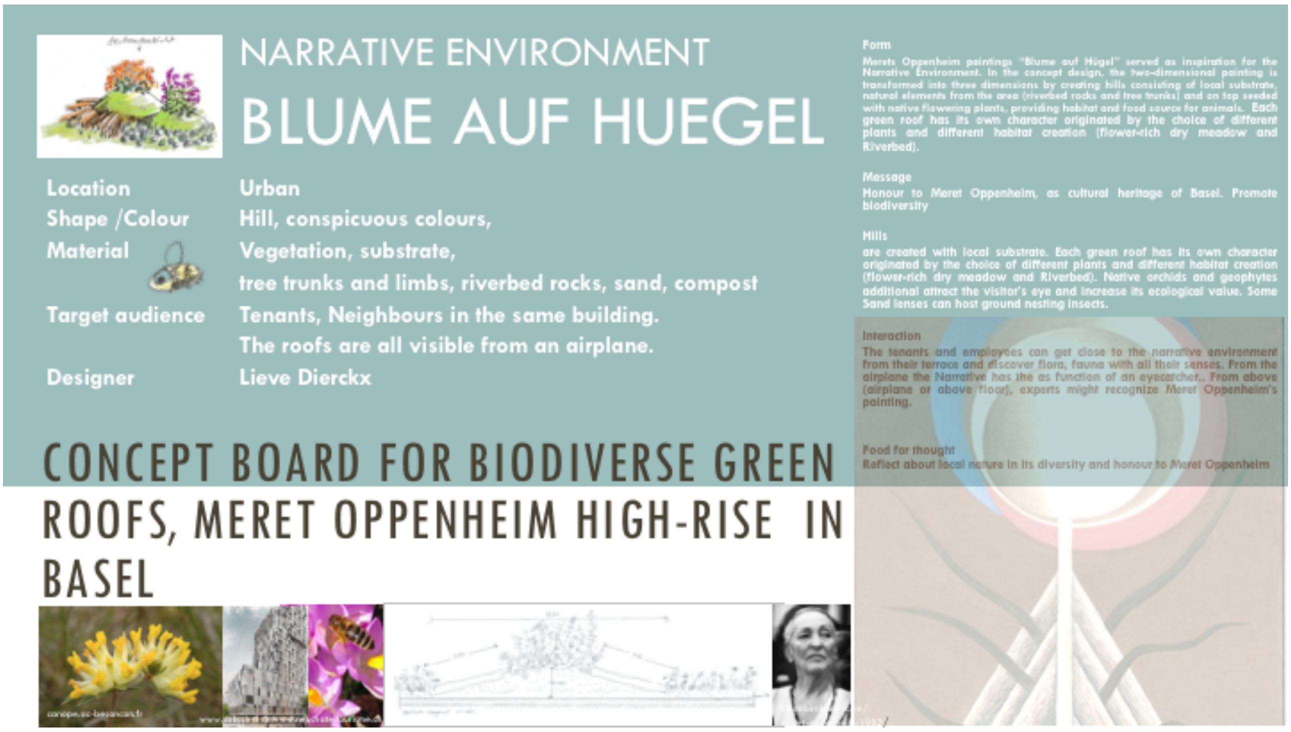
Step 5 in CoNaNalysis: Concept Formulation

Creativity method history of the future

To further test the feasibility of the concept the creativity technique *History of the future.* Due to time constraints, the author did not used the method of history of the future.

Concept idea and concept board

The concept is created to promote fascination and awareness for the biodiverse landscape in and around Basel. The diverse structured roof landscape offers an attractive variety of colours and patterns of flowers, grasses and plant structures, even in winter as the extensive maintenance regime leaves dry plant stems, which can also be used as habitat by wildlife. The flower hills are highlighted by rocks or dead wood trunks in a circular pattern that enhance the ecological effect and create an interesting graphic design element. The aim of the Narrative Environment is to attract the attention of the tenants, and from an airplane, the patterns of the hills might also be seen. The story of homage to Meret Oppenheim is continued in the Narrative Environment on the green roof.



Basic concept

Besides the cultural and artistic value of the Narrative Environment 'Blume auf Hügel', the concept aims to support biodiversity and commit to ecological compensation. Therefore, the roofs mimic different habitats such as unspoiled river banks of the nearby Rhine River and the ruderal and dry meadows habitats. Those habitats decreased enormously in the last decades. Since 1900, 95% of dry meadows disappeared, which is an argument for mimicking them on the roof (BAFU, 2015). Riverbank substrates contain mainly sand and gravel.

Different design elements increase creation of habitat:

A mix of sand, regional soil and little compost support the vegetation of near-natural dry meadows. Variations of substrate dept (10-12-16 cm) create low and higher vegetation and therefore different microhabitat conditions. Dry meadows, which are not mowed yearly, provide seeds in autumn for birds. The vegetation can offer habitat to more insects and spiders, a good food source for birds such as the native *Phoenicurus ochruros* black redstart. It can use the deadwood logs to hunt, or wild bees can lay their eggs. Other wild bees and the native *Oedipoda caerulescens* (blue winged grasshopper) prefer the sand linses on the roof. They live in stony and sandy habitats with sparse vegetation which they will find on the roof. The overall design provides a mosaic of microhabitats where plants and animals can colonize, all placed around the ‘hills with flowers’, a microhabitat itself. Since the wind is very strong on the upper floors (15th, 24th, 25th floor), logs will need to be fixated on the roof.

Native orchids will be planted on the roof and in autumn native geophyte onions brought out in the soil. These will provide nectar to pollinators in early spring. Seeds come from Swiss ecotypes, a mix of UFA Greenroof 49CH (UFA-Dachkräutermischung-49 CH) in combination with fresh hay from species rich dry meadows from Rheinacher Heide (Hay transfer method). For the flowers on top of the hill, a selection of single pollinator plants will be seeded (Anthyllis vulneraria, Papaver rhoeas, Salvia pratensis, Cichorium intibus, .

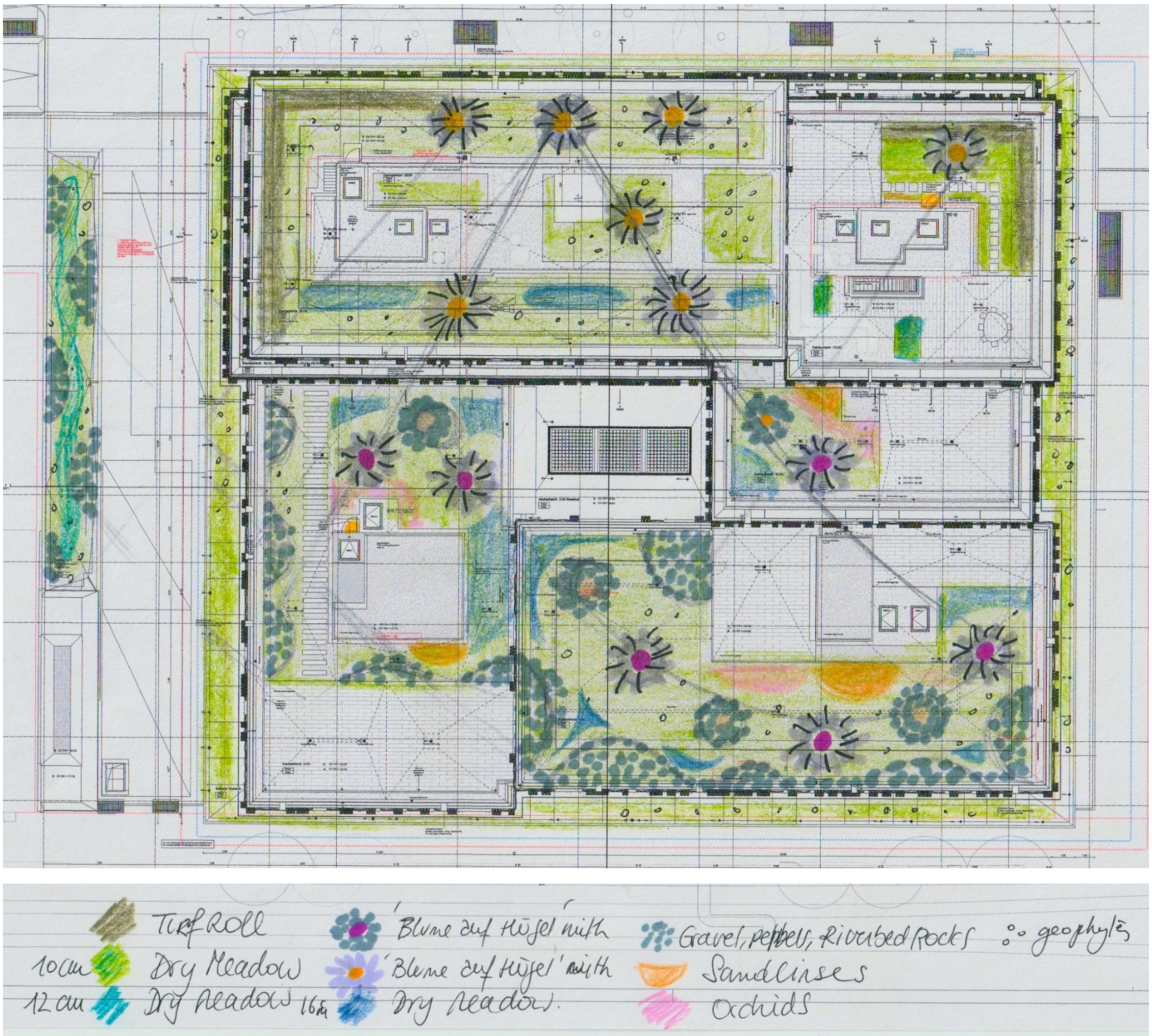


Figure 60: Draft visualistion of concept. L. Dierckx

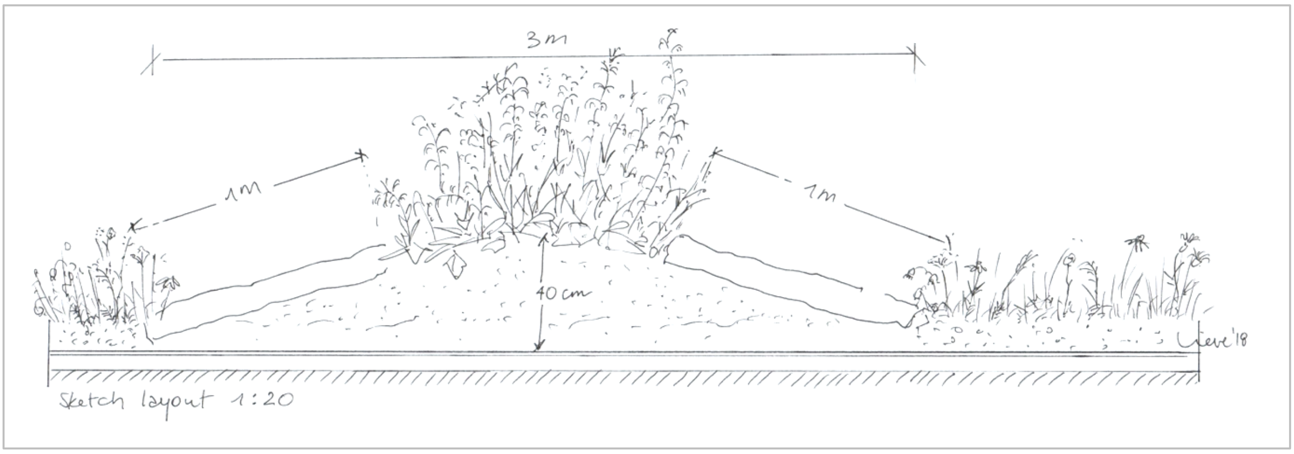


Figure 61: Blume auf Huegel: Visualizations: variation 1 is with river rocks, variation 2 is with dead wood. In the middle native flowers will be seeded. Scale 1:20 Sketsch: L. Dierckx.

Concept board and concept Idea

Figure 62: Habitat creation. Left and right: Green roof design with different substrate depts and substrates to create a mosaic of microhabitats. Canton hospital, Basel Klinikum 2. lower left: Nature like riverbed landscape on the shopping Mall Telli, Aarau. Image: L. Dierckx lower right: Dead wood and species rich meadow on a green roof Image: (Ruttensperger, 2017).

Further details on the design, substrate and plant choice per roof can be found in the Annex F

5 Discussion

5.1 CoNaNalysis

The method CoNaNalysis proposed in this paper consists of two major parts: site analysis and Concept Narrative Environment.

An important part of the site analysis is to capture the biotic and abiotic factors that will define the substrate and plant choice on the roof. The concept creation considers the socio-cultural and historical context of this analysis. The site analysis proposed as part of CoNaNalysis is very detailed. The author intended to provide a detailed guideline to cover all possible scenarios for all different starting positions. Depending on the expertise and experience of the designer as well as on the local situation and overall project goal, it can be shortened.

For the case study in San Francisco, the level of detail enabled the author to get the full picture of the site. For the case study in Basel many questions were redundant since (a) the building was still under construction, (b) there was limited access to the architectural plans, (c) the researcher was unable to interview the ordering party and target audience.

A shortcoming of the site analysis was, that for many factors, only a momentary impression of the site is given. The off-site investigation helps to mitigate this shortage. However, the author suggests paying more than one on-site visit to capture as many observations as possible to gain knowledge about the site. For the case study in San Francisco, due to the two-season climate that creates a completely different appearance of the vegetation, a visit in both seasons might be recommended. This was not possible due to time constraints. For the case study in Basel, a visit on the roofs after finalizing the high-rise construction might give a better impression on how the wind situation is on the upper roofs.

The creativity methods and evaluation of the narrative concepts in CoNaNalysis are inspired by methods for Narrative Environment proposed by (Jaeger, 2017) and (Mueller, 2011). The results show that they enabled the author to define criteria to decide and focus on one concept in each case study. For the case study Basel, the design element of a hill planted with appealing wildflowers in the concept "*Blume auf Hügel*" served as inspiration for Westpol Landscape Architects. In a modified form, it will be implemented on some of the green roofs of the Meret Oppenheim Building. This first result could indicate that the author captured the ~~environmental~~ socio-cultural context well and transformed it into a concept that is understandable and inspiring to other people involved. This can confirm the suitability of the method CoNaNalysis for this case-study.

In fact, the idea behind the two case studies was to experimentally test the method CoNaNalysis, to find out about its effectiveness in two different climate zones (Oceanic and Mediterranean) and two different types of buildings (a residential building and a high-rise). Indeed, each roof is an exclusive location with unique requirements that will offer different habitats depending on its particular situation in a unique environment (Dunnett & Kingsbury, 2004). Both case studies did not have an education aspect due to the target audience. For the San Francisco concept, the target audience was only identified after the appropriate test-building was found. A third case study, where the scope of the Narrative Environment is tied more to the educational value in the context of environmental topics and sustainability in urban areas—for example at a school building or a public library—, would have been favorable to also cover this aspect.

5.2 Research Question and Hypothesis

Within the framework of this paper, the research question "*How can incorporating a Narrative Environment into the design of biodiverse green roofs as a method provide guidelines for the design of biodiverse green roofs in a socio-cultural context?*" could be answered by creating the method CoNaNalysis that included the design of a Narrative Environment on a green roof. The method was experimentally tested in two case studies.

Hypothesis 1: *Green roofs offer suitable space for a Narrative Environment.*

Narrative Environments can be applied to any type of landscape or space (Jaeger, 2018) (Mueller, 2011). Thus, the author of this paper suggests that a Narrative Environment is ideal to be applied on a green roof. A Narrative Environment can serve as an instrument to help upgrade unaesthetically appealing extensive green roofs so that they can become attractive nature-like settings. This might be an instrument meeting Sutton's (2004) suggestions to make green roofs conspicuous, and to provide concrete experiences and discoveries of nature and art in this context. Additionally, the Narrative Environment created on the roof could help understand the role of green roofs in their commitment to mitigate the consequences of climate change, their role in connecting habitats and support for biodiversity. The effect of a Narrative Environment can be to develop a stronger connection to its place. Many senses can be addressed that can allow a holistic experience. It is evident that on biodiverse roofs which are not accessible to the audience, the visual aspect would be dominant. However, in this urban context, visual perceptions might be very intense since the surrounding urban environment usually builds a contrast (grey, concrete, rigid geometric forms of architecture) to what can be a very dynamic, vivid and colorful situation on the roof. This might compensate for the reduced involvement of other senses. For the San Francisco narrative, the tenant can get closer to nature on the roof, while watering the *Zinnia elegans* plants and therefore experience nature through several senses. For the Basel case study, visual interaction with the target audience is the most important aspect, since access to the Narrative Environment is not foreseen.

Due to the private character of the sites in both case studies, the roofs are not accessible to the public. The main goal of the Narrative Environment laid is therefore more in the artistic design of those biodiverse green roofs rather than in the educational aspect. Further case studies might be selected to create findings regarding the methods, when education within the context of the environment and sustainability is the main purpose of the installation.

The challenges for Narrative Environments on green roofs are related to the specific site conditions, such as limited load capacity of the roof, extreme weather and site-conditions, and limited access of a roof. Due to low maintenance requirements of biodiverse green roofs, the image of a dynamic vegetation needs to be part of the design of the concept. If these challenges are posed and considered in the Narrative Environment, and as shown in the two case studies, biodiverse green roofs can qualify as a good location for Narrative Environments in the context of environmental topics and sustainability in urban areas.

Hypothesis 2: ***In each region and climatological zone, native plants and native plant communities can be found to create a biodiverse green roof with different plant communities.***

Krupka (1992) pointed out that plants experience extreme conditions on a green roof. Other than on the ground, the most typical design element for creating Narrative Environment on green roofs is finding plants that are suitable. More specifically, finding native plants that fit in the Narrative Environment in terms of appearance (form, color, structure and texture) is one of the bigger challenges. The site analysis presented enabled to find native vegetation that suits the specific site conditions of a green roof for both climate zones and the specific site conditions on the roof.

For the San Francisco case study, many native plant communities host plants that are drought resistant and are adapted to the local site conditions. Many of these plants have a high ecological value since they provide an additional food source for pollinators. For the Basel case study, the choice of plants and habitat was mainly guided by the local requirement for green roofs, to compensate for a natural habitat. Most of these plants have been successfully used in different biodiverse green roof settings in Basel.

Hypothesis* 3: *In each region and climatological zone, natural materials can be found to design the roof.

In both case studies natural design elements could be found near the site. For the San Francisco case study, Pine cones, dead wood limbs can be found very close to the site. The design element crushed brick might be harder to find, as its production at Corona Heights stopped. Alternative sources could, due to time constraints not be further investigated. For the Basel case study, dead wood logs, natural soil and river rocks can be found in the area as well. Both results followed the expectations of the author. Therefore, Hypothesis 2 and 3 can be accepted for both study cases. It can be assumed that for other similar cases, similar results might be expected. More concrete projects might help to generalize this statement.

Hypothesis 4: (a) *CoNaNalysis provides* is a novel way to design aesthetically appealing biodiverse green roofs that can be highly accepted by visitors. (b) As a guideline, it can be applied to create green roof concepts in a socio-cultural context.

Part (a) of the hypothesis cannot be confirmed, due to lack of realization. Part (b) can be confirmed for both case studies. It can be used as a guideline to create green roof concepts that consider the socio-cultural environment.

However, the success of the result cannot be ensured. Regarding how the plant communities will develop over time, only estimations can be made since the concepts are not realized. Even if the selection of plants and substrate is based on profound investigation and site analysis, not all factors can be calculated in advance while designing with nature.

Also, the actual effect on the audience cannot be predicted, it can only be guessed based on similar research in this field (Baettig-Frey & Jaeger, 2018)(Mueller, 2011) (Sutton, 2014).

5.3 Conclusion and Outlook: adding Narrative Environments to an ecological design

Back in 2006, Brenneisen pleaded to see green roofs in the regional perspective of landscape and ecological planning, thereby enhancing the functional-technical approach by the spatial approach of conservation science practitioners. These requests, together with further worldwide research on environmental green roofs (see chapter 1) has led to the implementation of biodiverse green roofs. It also resulted in the inclusion of ecologically designed requirements in many local laws and regulations concerning green roofs. Likewise, local green roof manuals, such as for example the Green Roof Manual of the San Francisco Planning

Department, (2016) started presenting guidelines on ecological design. Likewise, some green roof developers, creators, and researchers commenced to understand the importance of supporting biodiversity in urban areas and set off to work together with local farmers, native plant nurseries or forestry departments to gain access to local seeds, substrate and natural materials. However, the author, while listening to feedback from visitors on natural green roofs, experienced that the acceptance from the audience is still not always fully embracing due to lack of understanding of the designed nature on a self-sustaining biodiverse green roof.

Indeed, often extensive and biodiverse green roofs do not look esthetically appealing at all times. Natural self-regulating biodiverse green roofs that mimic natural habitats are often not well understood. They are not perceived as “beautiful”, and the interaction with the public is missing. Green roofs are designed with plants whose appearance are subject to temporal and spatial dynamics. This means that due to vegetation dynamics, there are times that nature does not look aesthetically attractive. Audiences sometimes do not understand that brown zones without flowering plants in the summer carry many seeds that might sprout again the following spring. Logs and rocks that create microhabitat on the roof are seen as a disorder. In other words, the ecological aspect, the connection to nature dynamics, and the self-regulating order of nature are not always recognized—and therefore eventually not desired on a green roof. Thus, a deeper understanding and more positive emotions for the visitor are desired, so that visitors can better connect and identify with urban nature (Sutton, 2014).

Sutton suggested (Sutton, 2014) to combine knowledge of ecology with artistic design to increase appreciation and acceptance of natural green roofs.

Baettig-Frey & Jaeger, (2018) describes a garden, as “a rich cultural and spatially complex environment” (p.2). A rooftop, in contrast, is often is like an empty sheet but surrounded by a rich, multilayered urban space. The author sees here an opportunity of Narrative environments, to tell the urban story by creating a green roof that becomes an integral and lively part of this cultural space. By watching plants grow or listening to bumble bees on a green roof nature and biodiversity becomes individually experientable from different perspectives. That way, people can (re)-connect to their own story, to life and they might develop a deeper understanding than when only looking at facts and figures.

For this Bachelor thesis, the intention was to propose a possible method to link ecological design requirements with an esthetical element as well as cultural connectivity; with the goal to promote biodiversity and help increase the acceptance of these types of green roofs. This paper presented the concept of a Narrative Environment on the green roof to enhance the esthetical design and to help the audience connect with nature. The method CoNaNalysis aimed to create space for nature on a roof as well as space where people can interact with their environment (see Figure 63).The author tried to close the gap between "what does nature?" and "how does the audience perceive it?", the gap between nature and culture, by joining the ecological green roof design into a human-focused social and cultural context. Hence, the author created the method CoNaNalysis that brought site analysis and Narrative Environment together. She also tested it on two concepts in two case studies with very different starting positions.

Figure 63: Experience nature on a roof: Is this a Narrative Environment on a green roof? Dudleya farinosa on the Drew School test roof, June 28, 2016. Lieve Dierckx

The research presented here demonstrates that CoNaNalysis enabled to create biodiverse green roof concepts with a Narrative Environment in the case studies of San Francisco and Basel. Yet, due to the inherent limitation of having only two case studies, these results cannot be generalized. Further case studies will be needed to analyze more deeply the potentials of the method and its general effectiveness.

The method CoNaNalysis is innovative since it provides a tailored site analysis and combines it with the techniques of Narrative Environments

In addition, CoNaNalysis focused on the concept and not on the concept realization. None of the concepts were implemented on the investigated roofs. Putting those concepts into practice on the roof will be needed to evaluate the effect on the audience of the Narrative Environment on these green roofs.

Additionally, more experimental case studies to test the effect and efficiency to accept the green roof, could be realized. For example, half of the roof could be designed with a Narrative Environment, the other half as a reference plot without Narrative Environment but using the same species composition and natural elements.

Finally, the author hopes that CoNaNalysis might lead to an increase in installations of biodiverse green roofs, no matter the size of the green roofs. She encourages green roof designers to include the design of Narrative Environments in green roof concepts and to inspire people to enjoy and to (re)connect to nature.

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Tables

Annexes

Annex A - Tables to CoNaNalysis

The three steps are explained in detail in Table 17 to Table 22. They show the different factors that need to be analysed in the first column and provide details or questions kin the second column. In the last column, the material needed for the analysis and research is also quoted for the off-site research. For the on-site research the result is noted.

Material

Before going through the separate steps of CoNaNalysis, first is the list with required material to perform this analysis.

Table 17: Material list for off-site and on-site research and observation.

Item	Details
Contact list	• Structural engineer • Property owner • Target audience • Architects • Artists • Designer
Plans / pictures / maps	• Architectural map including load factors, slope • Inventory plan, cadastre plan, pipe plan, situation plan, • Photo documentaries • Maps of the surrounding, 1:25 000, 1:100 000, online maps
Project documentation	• Contains for example details on the age of the project, the background of the project and the budget
Pen and paper, checklist, measuring stick	• For on-site observations
Notebook, camera (smartphone)	• For research and documentation, photo documentaries

Site Analysis in CoNaNalysis: 3 STEPS

The three steps are explained in detail below. The tables below (Table 18 to Table 20) show the different factors that need to be analysed in the first column and provide details or questions in the second column. In the last column, the source of information needed for the analysis and research as well as the outcome is also quoted.

Step 1 in CoNaNalysis: Off-site research

Table 18: Details of the off-site research on CoNaNalysis. Source of information: SE= Structural engineer, AM= Architectural maps, ARM= Area Maps: R= Research, M= Measurement, I = Interview, PD= Project Documentation. Result: L = List, D = Drawing, I= Interview, N = Notes. created by author.

Structure and installation		
Factor	Details	Source / Outcome
Structure	• Design loads for the roof structure • Exposure to roof surfaces • Deflection of precipitation by the structure • Existence of any major plants and exposed pipework on the roof • Gradient of slope of the roof surfaces	SE AM /N
Installation (plant)	• Current drainage arrangements on the roof • Water requirements • Power supply requirements (for lightning and equipment) • Roof access • Lightning conductor on the roof • Safety facilities	AM /N
Abiotic hard factors: Climate, weather, topography, geology and orientation		
Factor	Details	Source / Outcome
Climate	• Macroclimate, seasons, incidents of periods of droughts • Mesoclimate • Regional Climate • Local microclimate (Light/ Temperature)	R /N
Air quality	• Airborne contamination	R
Weather Wind and Temperature Hydrology	• Pattern and amount of precipitation: rainfall, snow and hail • Any incidents of periods of droughts? • Direction of prevailing wind • Wind flow conditions and wind uplifting effect on the roof • Tornadoes • Temperature • How much water is received from rain, sleet snow and morning dew or fog?	R, M /N

Light conditions	• Shadowing effect of surrounding buildings on the roof • What is the amount of sunlight? • Average exposure to sunshine	ARM /N
Topography	• Extreme proximity to sea or high on a mountain • Slope and size of the area, do they have impact on plant selection? • Earthquakes • Different altitudes of the roofs	R AM M
Geology Substrate / Soil	• What is the bedrock and strata of this area? • What is the first layer of rock or of other geological arrangements? • What is the type of soil, the particle size distribution, the humus content, the PH-value, the mineral nutrient, the heavy metal content, the water holding capacity and the water permeability	R M
Orientation	• What is the orientation of the green roof?	AM
Biotic hard factors: vegetation and wildlife of the surrounding area		
Factor	Details	Source / Outcome
Vegetation	• What plants have been found in the surrounding area?	R / list of plants
Wildlife Connectivity	• On and around the site: "What fauna did exist historically, exists now and are possible in the future?" • Is there known corridor for specific animal species?	R ARM / list of animals
Soft factors: location and environment Immediate socio-cultural and historical context as base for finding Narrative Environment concepts that suits to the environment and considering the project mapping, the ordering party and the target audience.		
Factor	Details	Source / Outcome
Framework Condition and Contract Users / Use	• What is the theme of the contract? • What are the framework conditions? • What is the legal framework? • Where is the location of utilization? • Which type of green space is desired?	R, I, PD ordering party and or target audience
Type and main function of the green space	• Which utilization will take place in this green space? • Which features does the planting need to fulfil to meet the planned utilization • What is the main function of the planting?	

Duration Maintenance Resources	• What is the expectation in terms of lifetime of the vegetation at this location? • How much time do you have for the maintenance?	
Ordering party	• Who is involved in the project? • Who is the ordering party, and which are their values? • Which projects exists already in this field? • Existing similar project of the ordering party? • What is the field of activity of the ordering party? • Does the ordering party use already specific technologies and communication media?	→ Draft: Analysis of utilization intensity → Draft: Type and site of utilization
Target audience	• Who is the target audience and future users, what and where do they work? What are their hobbies? Where do they travel to? • What is their lifestyle aspiration and what are their values?	
Economical demands	• What is the project budget? • What are the financial resources for this project?	R, PD
Socio-cultural and historical context (environment)	This factor captures the spirit of the age, actual trends, prevalent values in different milieu of society. • What type of location is it? (urban) • What are the cultural and natural assets on-site (customs and traditions)? • What are the political components of the location • What is the character of the inhabitants • What is the history and development of the location? • What are the dimensions of the landscape • Which elements are disturbing?	R
Goal of the Narrative Environment: before, during and after analysing and evaluating the research information, questions about the goal of the Narrative Environment can be addressed. During the whole process of creating the concept, this can be modified, depending on the scope of the designer and the outcome of the site analysis on-site.		
Factor	Details	Source / Outcome
Goal of the Narrative Environment	• What are the goals? (Adventures for the audience, transfer of knowledge Sensibilities on certain aspects, built competence related to environmental education or education for sustainable development, develop new or specific images of nature? Change behaviour of the visitors? • What is the short-term goal?	R PD

	• What is the long-term goal? • What can the audience learn and experience? • What is the take-home message of the Narrative Environment?	

Step 2 in CoNaNalysis: On-site visit of the area

Table 19: Step 2 of Conanalysis: On-site visit of the area. Factors, details and outcome. RO= On-Site Observation of the roof, Source of information: RA= On--Site Observation of the surrounding environment. Result: L = List, D = Drawing, I= Interview, N = Notes

Abiotic hard factors: Climate, weather, air quality topography, and geology		
These factors have been researched and measured off-site. Observations on-site can help to better understand the impact of these factors for the roof project.		
Biotic hard factors: vegetation and wildlife of the surrounding area Diversity, quality, connectivity and nature management of the surrounding area		
Factor	Details	Outcome
Vegetation, microflora and Plant habitat Connectivity and quality of the surrounding area	• Are there open green spaces (e.g. meadows, lawns), hedges and planting groups of trees, dry-stone walls that continue in the areal next to the areal of investigation? • Are there open water bodies as element of connectivity on the areal? Is there a water body in the neighbour areal available? • Are the plants native and according to the site conditions? Do they look vital? • Are there neophytes on the areal? When yes, are they invasive?	L or D
Diversity of structural elements	• Which structural elements are available? Ruderal sites, meadows and lawns, ground cover, hedges, perennials, facade greening, green roofs, trees, overgrown tree bases, potted plants. • Is there a high diversity within the single structures? • Are the structural elements old (enables a more diverse habitat)? • Which small structures are available? Dry stone walls, path slabs, pile of stones, pile of branches, piles of leaves, pile of deadwood, untreated wood fence, nesting aid for insects or birds, compost • Waterbodies: are ponds or streams available.	L or D
Wildlife Connectivity	• Observation of wildlife	L

Soft factors: location and environment		
Immediate socio-cultural and historical context as base for finding Narrative Environment concepts that suits to the environment and considering the project mapping, the ordering party and the target audience. Some of the aspect can be researched off-site.		
Factor	Details	Outcome
Socio- cultural and historical context (environment)	This factor captures the spirit of the age, actual trends, prevalent values in different milieu of society. • What is the atmosphere of the location? • Which megatrends are present or relevant? • Wat is the human and social interaction? • Are there any patterns of people recognizable? • Are there existing Narrative Environments that can be source of inspiration?	R
Goal of Narrative Environment	• Are there specific aspects of the area that can change or define the goal of Narrative Environment?	R PD
Material specifications on-site	This helps to incorporate site specific elements in the Narrative Environment. • What material is available?	L

Step 3.in CoNaNalysis: On-site inspection on the roof

Table 20: Step 3 of Conanalysis: On-site inspection on the roof. Factors, details and outcome. RO= On-Site Observation of the roof, Source of information: RA= On--Site Observation of the surrounding environment. Result: L = List, D = Drawing, I= Interview, N = Notes

Structure and installation		
Factor	Details	Outcome
Structure	• Design loads for the roof structure • Exposure to roof surfaces • Deflection of precipitation by the structure • Existence of any major plants and exposed pipework on the roof • Gradient of slope of the roof surfaces	N (D)
Installation (plant)	• Current drainage arrangements on the roof • Water requirements • Power supply requirements (for lightning and equipment) • Roof access	N (D)
Abiotic hard factors:		

Climate, weather, topography, geology and orientation		
Factor	Details	Outcome
Climate	• Local microclimate (Light/ Temperature)	N
Hydrology	• How much water is received from rain, sleet snow and morning dew or fog?	N
Weather Light conditions	• Sun • Shadowing effect of surrounding buildings on the roof • What is the amount of sunlight? • Average exposure to sunshine • Areas exposed to the sun and shade areas on the roof • Extreme sites, problem zones on the roof?	D
Climate / Wind Temperature	• Wind on the roof (extreme site) • Wind flow conditions and wind uplifting effect on the roof • Temperature on the roof (extreme site)	N (D)
Topography	• Slope and size of the area, do they have impact on plant selection? • Different altitudes of the roofs	D
Biotic hard factors: vegetation and wildlife of the surrounding area Diversity, quality, connectivity and nature management		
Factor	Details	Outcome
Vegetation and wildlife	• Observation of spontaneous vegetation and wildlife on the roof	D, L
Soft factors: location and environment Immediate Socio- cultural and historical context as base for finding Narrative Environment concepts that suits to the environment and considering the project mapping, the ordering party and the target audience. • Material specifications on-site helps to incorporate site specific elements in the Narrative Environment.		
Factor	Details	Outcome
Personal style, Creative and design demands Connections, perspective lines, spaces (owner or user)	• What are the tastes and preferences in terms of colours, favourite plants? • Which type of space is wanted? • How is space created? • Is there a need to create new space by plants or emphasis existing space by plants? (depends on use and needs) • Is sight protection available? Is it desired? Are visual axes with the environment considered? Where are insights allowed, where not? • Who has insight in the green roof?	I, D

Visual axis: Inside and outside views		
Material specifications on-site	• Which of the available material can be used?	L

→ the Outcome is a photo documentation or a Mood Board concerning the existing themes

Concept Development and Concept Formulation in CONANALYSIS

Step 4 in CoNaNalysis: Concept Development: tell stories and find ideas.

Table 21: Step 4 in CoNaNalysis Concept development. Factors, details and outcome. RO= On-Site Observation of the roof, Source of information: RA= On--Site Observation of the surrounding environment. Result: L = List, D = Drawing, I= Interview, N = Notes

Concept Development: tell stories and find ideas.		
Factor	Details	Outcome
Idea finding, creating a story Materialization	• Do the ideas and the story fit the context and the story of location, so that identification is possible? • Can the idea be materialized by plants and natural elements?	N
Evaluation of the three concept ideas	• Is the target audience addressed? • Are the goals clearly defined? • Is the story recognizable? • Is the idea feasible?	three concept ideas
Rating of the three ideas	The three concepts are evaluated (rated) by the author in terms of • Is the concept feasible? • Does the concept unfold artistic and narrative potential? • Is the concept easy comprehensibility by the audience	Once concept
Develop and refine these ideas	• Is the effect of the Narrative Environment strong enough but not too much?	One concept

Step 5 in CONANALYSIS: Concept Formulation

Table 22: Step 5 in CoNaNalysis: Concept formulation. Factors, details and outcome.

Concept Formulation		
Factor	Details	Outcome
Fine tuning of the final concept via the visioning method *History of the future*	• What are the strengths and weaknesses of the concept?	concept board

The concept board will be complemented with a more detailed description of the base concept. To with the following documents to enable the realization of the concept on the green roof:

Elaboration up to base concept:

Description of base concept

Visualisation of

- Vegetation: Plant list
- Substrate: Thickness, composition, design→ description and visualization on map
- Maintenance plan

ANNEX B - Case Study San Francisco

Questionnaire for the property owner, W. Carpmill. L. Dierckx, August 20, 2017.

Actual situation

What do you like about your roof, what is special about your roof? (e.g. Location: Spectacular View of the City)

“It is a quiet location with wonderful views of downtown SF, SF Bay and East Bay Hills, including Mount Diablo. Open space behind the house.”

What is special about this neighbourhood to you?

“My family moved to this neighbourhood in the 1840’s, before it was a neighbourhood. It still is a charming, quiet neighbourhood with fresh air and several large public parks.”

What makes this location unique?

“It is almost the exact geographical centre of the city and is a bio-zone that crosses the ocean and the bay together.”

Any funny, sad, interesting stories or memories about this neighbourhood or location?

“There is an amazing geological formation right behind the house.”

https://ww2.kqed.org/quest/2011/07/07/geological-outings-around-the-bay-the-great-slickenside-of-corona-heights/
http://blogs.agu.org/mountainbeltway/2015/12/28/corona-heights-fault-san-francisco/

What did you like the most when you spent your time in this neighbourhood as a kid / and now?

“As a kid, I would come to the house to visit my great grandma, so of course, her cookies and pastries ☺. The view from the front room, at the time was amazing because there were many ships on SF Bay. Also, there is a great playground in the park behind the house, with a huge swing set and a merry-go-round, a few slides, and the slickenside rock face to climb.”

Goals and Objectives / Design concept / use of space

These questions relate to your core values, lifestyle and priorities and help me to identify your desires.

Is beauty important?

“Yes, beauty makes life tolerable ☺”

How do you expect this garden to define you?

“I don’t expect it to define me. I expect, though, that a “living roof” helps make a statement that I’m interested in the environment, doing what I can to help create habitat, and willing to try new/old things.”

Form versus function? Is one more important than the other?"

"Function is essential. Hopefully form shows through, but if it fails, or leaks, the form would have to be ripped out to do repairs :(so function above all else."

What do you want the space to provide for you?

"A garden to hang out in, to be able to bring more of the lifestyle into the outdoors, maybe a spot to grow some veggies (sunlight is better on the roof and the back yard is tiny, with many tall structures blocking sun)."

How do you like to spend your time outside on the roof?

"I imagine evenings for relaxing. I'd come out in the day to care for it a bit, but I don't do well in sunlight (sunburn etc.) so I wouldn't be sunbathing. I'd probably need an umbrella."

Do you like to eat outdoors on the roof?

"Sure, in summertime."

Are biodiversity and ecology important to you and would you like to bring elements to the roof?

"Absolutely - this would be my main interest to be honest. There are a few native species in our neighbourhood - butterflies and moths, and a lizard or two, and helping to create an environment that is healthy for them would be awesome."

Do you like the native vegetation of this area?

"Yes, it is a mix of chaparral/salt tolerance and more inland plants, due to the fact that the west side of our hill/neighbourhood still gets a fair amount of salt from the ocean. My favourite environment is the woods, forests, mountains but our neighbourhood is pretty special."

Does the use of water guide you for the living roof (I am thinking of drought resistant plants)?

"Absolutely, water is expensive here."

What kind of plants (names or picture or description e.g. grass like, bamboo like, …) do you like a lot? What plants are your favourites?

"Hard to say - I imagine a mix of grasses and succulents would do well and both are varied and beautiful."

What kind of plants do you NOT like?

"Poison ivy, triffids :)"

Do you like more pastel colours or powerful colours, any colour palette or colour preferences for the plants?

"Pastels, although I would like a spot on the roof to grow some annuals like zinnias (one of my favourites)".

Beside an extensive part of the roof, where there is no access for people but space for a natural living roof would you like to have

Would you like a deck to sit on? *"Yes"*

Would you like planters?	*"Yes"*
Would you like vegetables?	*"Yes"*
Would you like trees?	*"No"*
Would you like shrubs?	*"Maybe"*
Would you like grasses ?	*"Yes"*
Would you like native plants?	*"Yes"*
Would you like exotic plants?	*"No"*
Would you like evergreen plants?	"Yes"

Artistically elements

"I would like to try bonsai"

Maintenance/ watering

How much time would you be able to spend for maintenance (watering, selective weeding, controlling) on the roof?

"Weekly or more"

Would you hire a gardener rather than doing the maintenance yourself?

"Not until I get too old!"

Technical data

How could the roof be accessible (now and how would you like to have it)?

"There's a ladder located in the backyard. Yes - since the lot is cut into the hillside, it would be possible to install a ladder to the roof from the back deck which would only need to be one story."

Would you like to access through the roof hatch?

"Yes, part of a design would include a spiral staircase from the central solarium up to the roof."

How many people can live in this house, how many bedrooms, ft2?

"Three bedrooms, approximately 2300 sq. ft. Probably could comfortably have 5 occupants. Note that the house is really two complete units - two bedrooms upstairs + one bedroom downstairs."

If you rent your house, what would be the Income per year tenants need to have to be able to afford it.

"At $8k/month = $96k per *year. I would estimate $300k per year to be comfortable.*

Annex C - Case Study San Francisco

Site Analysis: Plant list and vegetation in the backyard on the property

The following non-native plants were planted or spontaneously colonized the backyard:

Tecoma capensis (orange bells), *Ficus carica* (fig tree), *Ricinus communis* (Castor bean plant), *Camelia japonica* (Camelia), *Rosmarinus officinales* (Rosemary), *Rubus fructicosus* (blackberry), *Cyperus papyrus* (Papyrus), *Pelargonium sp.* (geranium), *Brugmansia sp.* (Angels Trumpet), *Salvia leucantha* (Mexican sage), and some Asteraceae species. The only native plant present was *Hedera helix* (Ivy).

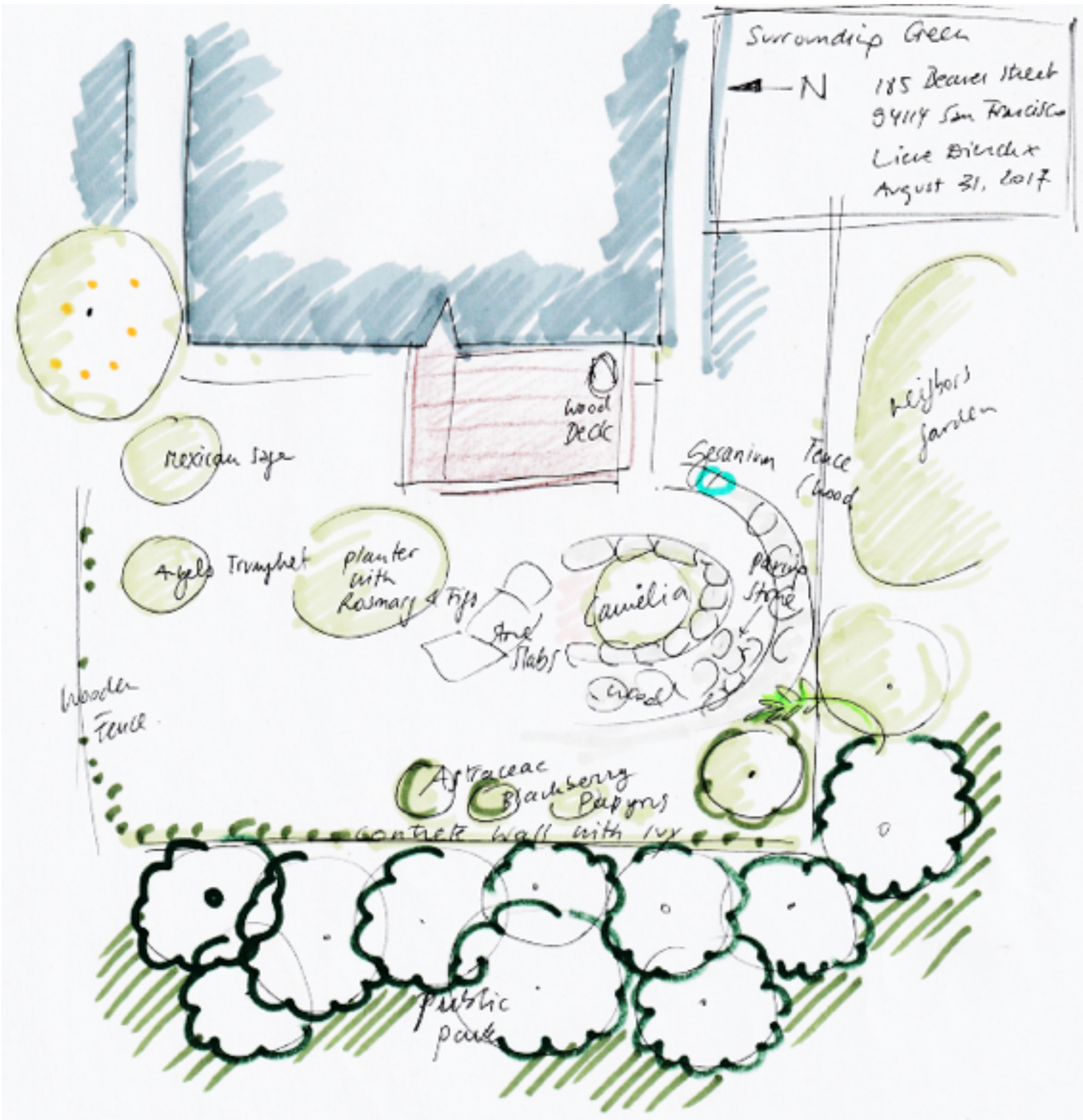


Figure 64 sketch (not true scale) of the situation on the site at 185, Beaver Street. L. Dierckx

ANNEX D - Case Study San Francisco

History of the future.

It is May 31; sunny spring weather and we are sitting on the deck of Will Carpmill's green roof at 185 Beaver Street. While drinking espresso, we are enjoying a wonderful view on the green roof and the panorama over San Francisco Downtown and Bay. This biodiverse green roof was built 2 years ago. Native wildflowers turn the roof into a magic sea of pastel and bright colours. Looking closer, a pattern of concentric circles can be recognized. It appears that each circle hosts other plants, and the circles are separated by natural materials. I know these plants, I have seen them around, but never paid so much attention to them. I see plants that I saw blooming near the ocean, others near twin peaks. I even see dry grass, golden similar to the grassland we know so well in California. I see pinecones, dry tree limbs, red rocks, all materials that we recognize from our green space in and around San Francisco. Amazing how these elements are integrated in this design concept. Some succulent plants escaped their circle, growing between the rocks. Maybe they feel better there? Watch out, a wasp! No, it's a wild bee looking for nectar and pollinating those beautiful flowers. To my surprise, I even see garden plants in the centre of the circles; that must be the special wish of the customer! The whole green roof is dynamic and full of life, just like San Francisco itself. It's a unique experience.

How did the author come to this idea of interference? First, the terminology: Interference is a term (notion, concept) from physics. It describes the overlap of two or more waves after the superposition principle. The Energy of the waves expand or overlap circularly according to the term interference from physics or also in a figurative sense. Therefore, the term of interference has been chosen for this concept. In the dictionary, the following explanations can be found:

> "interference [in-ter-feer-uh ns] / /*ˌɪntəˈfɪərəns/* noun
>
> 1. an act, fact, or instance of interfering.

2. something that interferes. It clarifies that an interaction, a mutual influence between two or more objects take place." (Dictionary.com LLC, 2018)

The author gets her inspiration for this Narrative Environment concept from research, taking considerations as well from observation of events of nature and cultural phenomena in and around San Francisco. The author again and again comes across the idea of waves and their interactions as the main themes in San Francisco.

The author was intrigued and inspired by the ocean on the west coast near San Francisco, which is constantly changing waves and used by surfers. It is a play of light and movement, sand and water, pastel shades and intense contrast. This landscape image from a city on the West Pacific Coast characterizes San Francisco.

The increased risk of earthquakes caused by the San Andreas and Hayworth faults shape the city and its inhabitants. Seismic waves create movement and impact the landscape.

Additionally, San Francisco, as a modern the city releases continuously new waves of renewal. Waves that flow into each other and mutually reinforce (positive interference) or cancel each other out (destructive interference).

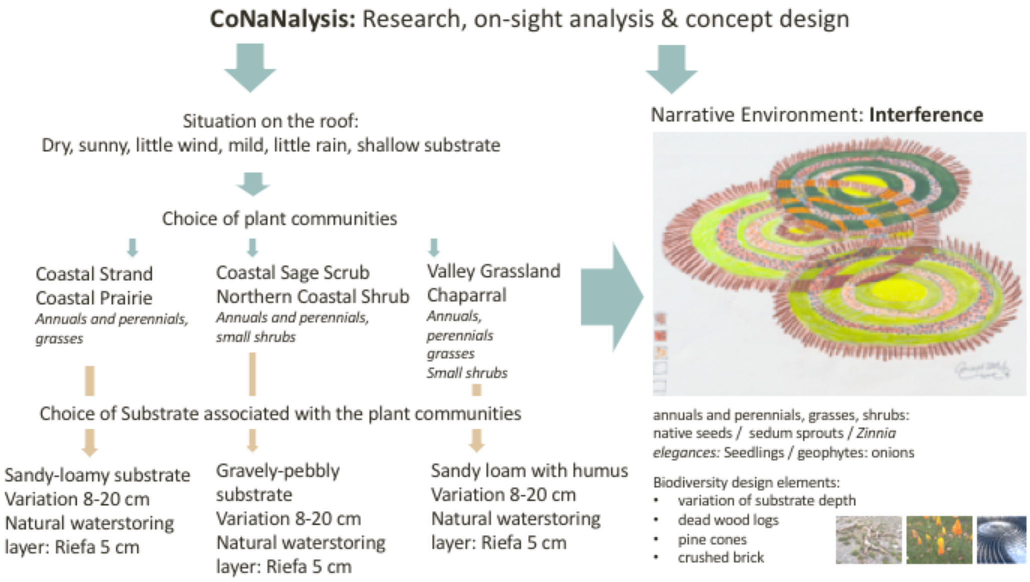
In San Francisco, many megatrends become observable. Examples are urbanization, health, neo ecology and connectivity. These themes often overlap.

Another aspect of waves that is perceptible in California is the wind. When rhythmically rolling over the green or golden meadows or waving over a grass based green roof in the city, a visual and audible happening can be encountered (Relaxing Sound).

When it rains, the principle of interference is clearly visible. When raindrops fall on a water surface, it can be observed that each raindrop causes several concentric waves with different radii. Some circular wave groups meet each other. In this intersection points, interference is visible (see Figure 32).

ANNEX E - Case Study San Francisco

Base concept Interference plant list and construction



One set of concentric circles will host plants from the coastal prairie and coastal strand pant communities.

Coastal prairie and coastal strand

Substrate	Sandy-loamy substrate (70% sandy Loam + 20 % Sand + 10 % city compost)
Waterstoring layer	Riefa 5 cm
Substrate depth	Variation between 8 and 20 cm
Vegetation	Use native seeds (from seed collecting, native plant nursery)
Natural elements	Pine cones, wood trunks and limbs, crushed brick

The second set of concentric circles will host plants from the coastal sagebrush and coastal strand pant communities.

Coastal Sagebrush and Northern coastal shrub

Substrate	Gravely-pebbly substrate (70% gravel and pebbles + 20 % Sand + 10 % city compost)
Waterstoring layer	Riefa 5 cm
Substrate depth	Variation between 8 and 20 cm
Vegetation	Use native seeds (from seed collecting, native plant nursery)
Natural elements	Pine cones, wood trunks and limbs, crushed brick

The last set of concentric circles will host plants from the Valley grassland and Chaparral communities.

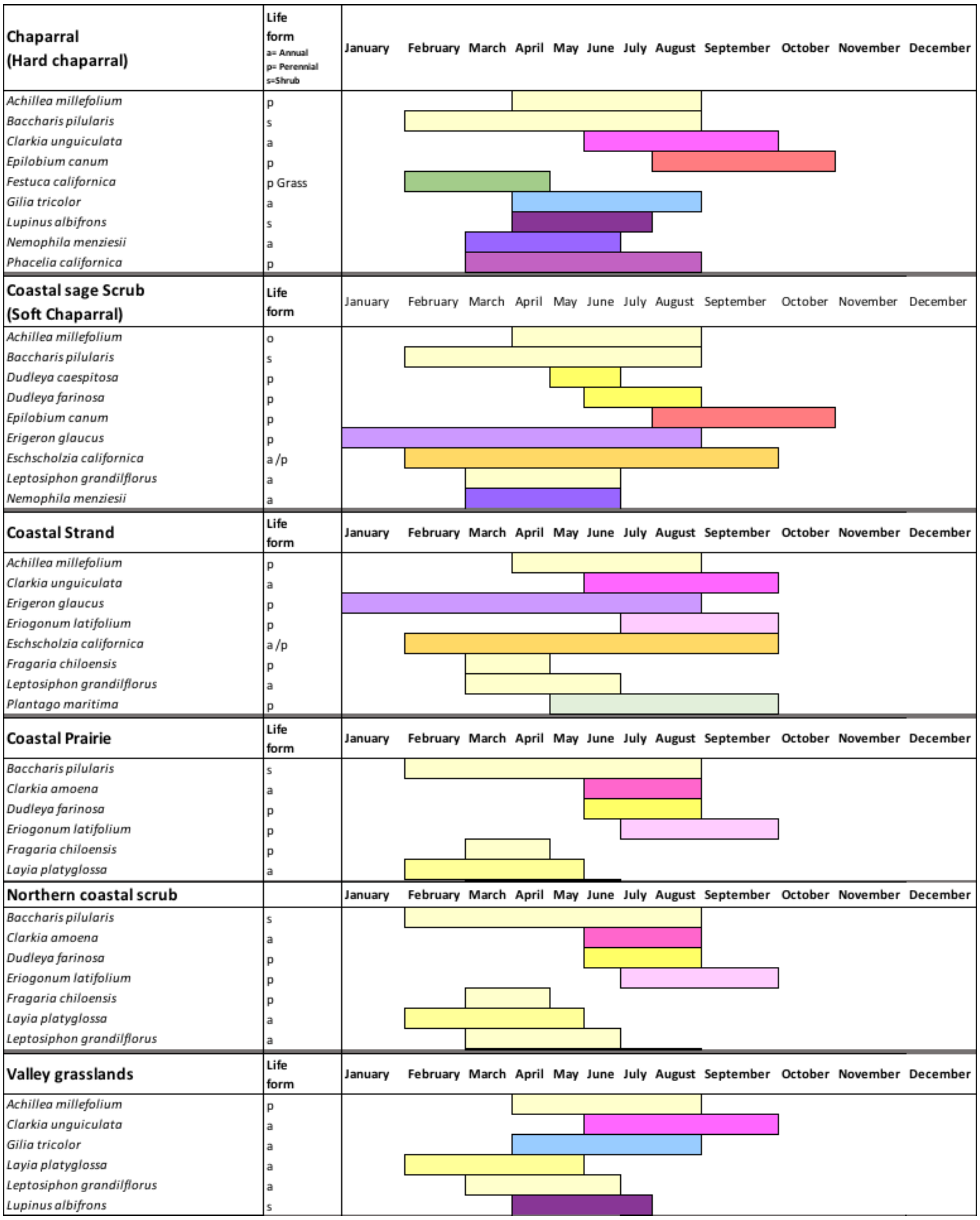
Valley grassland and Chaparral

Substrate	Sandy-loam substrate with humus (60% sandy Loam + 15 % Sand + 25 % city compost) Waterstoring layer Riefa 5 cm
Substrate depth	Variation between 8 and 20 cm
Vegetation	Use native seeds (from seed collecting, native plant nursery)
Natural elements	Pine cones, wood trunks and limbs, crushed brick

Further elements:

Zinna elegans	Garden soil
Deck	Redwood boards

Table 23: Possible plant list for concept Interference. Based on plants



ANNEX F - Case Study Basel

detailed concept data per roof: example for 25 th floor. South exposition

25 th South

Function / target audience	Technical roof / Airplane guests only
Elevation (rounded to 0,5)	82
Orientation	South
Site characteristics	High altitude and dry, **very wind exposed**
Blume auf Hügel 25 (7 hills)	
Plant selection	Seeds *Anthyllis vulneraria* (kidneyvetch)
Ecological value	Good pollinator plant for bees
Choice of Substrate associated with the plant communities SIA 213 Quality standard 'green roofs'	Basler extensive Substrate 30 % Sandy gravel (0-30mm) 40 % Mix compost- Natural soil 30 % Lava -Pumice
Substrate depth	20 cm / underneath: 20 cm XPS-boards
Natural element	Dead wood logs, 1 m long 15-20 cm diameter
Maintenance	Initial watering Eventually 2-3 times / years weeding to keep vegetation picture Eventually re-seeding after two years
Surrounding green	
Plant selection	Sedum, flower Meadow (UFA 49 Flower meadow) and grass roll matt in the edges
Choice of Substrate associated with the plant communities SIA 213 Quality standard 'green roofs'	Basler extensive Substrate 30 % Sandy gravel (0-30mm) 40 % Mix compost- Natural soil 30 % Lava-pumice Substrate depth: 1/3 10cm, 1/12 cm/ 1/3 16 cm.
Substrate depth	10 cm
Maintenance	Initial watering
Ecological value	Habitat creation / Plants for pollinators

Poster

Methodical and design concept for the development of natural green roofs with a Narrative Environment

Applied to the case studies Meret Oppenheim High-rise in Basel and a Residential Building in San Francisco

Introduction

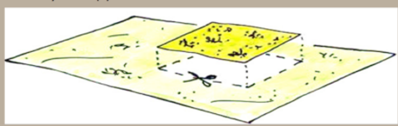
Biodiverse green roofs can bring biodiversity into urban areas and commit to sustainable architecture. Many research methodologies on creating biodiverse green roof concepts emphasize only on site-analysis of the structural and ecological functional aspects. The esthetical and socio-cultural context is often left aside. Therefore, a strong connection with nature is not established and the green roof cannot be fully enjoyed and understood. Narrative Environments are communicative environments created in space, which can enable a new experience and deeper understanding of nature and culture.

The main focus of this thesis and the research question is:
How can incorporating a Narrative Environment into the design of biodiverse green roofs as a method provide guidelines for the design of biodiverse green roofs in a socio-cultural context?

This paper develops a method called **CoNaNalysis.** Its name stands for Concept, NAture and NArrative-Environment anaLYSIS. It combines site examination in its functional aspects with the techniques of a Narrative Environment.

Material and Methodology

This thesis investigates methods for the connection of Narrative Environments and green roofs with focus on promoting biodiversity. Two methodologies (a) Site Analysis and (b) Narrative Environment method.



Img. 1: Site-analysis: Green roofs are connected to its surrounding environment.

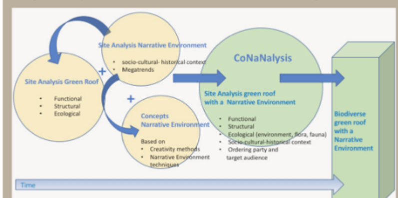
Sight analysis is an important method to help to define parameters for the design and construction of a green roof (Dakin et al., 2013). Three different standard methods of site analysis from a different field are described and evaluated on their effectiveness as methods for designing green roofs. (a) the site analysis after the FLL Guideline for Green Roofs, (b) Method Site Analysis (Inventory) from the field of landscape design and (c) Ecological Planning Method.

Each method is derived from a different field being green roof construction (FFL), landscape design (Inventory) along with ecology (Ecological planning). The second method, based on Jaeger (2010, 2017) and Mueller (2011) is used to create a Narrative Environment (in the context of environment and sustainability). In light of this perspective, this paper develops the method called **CoNaNalysis.** It aims to create space for nature on a roof as well as space where people can interact with their environment. To support and test this new method, two different concepts for natural green roofs with Narrative Environment were created, both in different cultural and climatological environments.

The first case study is the high-rise Meret Oppenheim in Basel, with Oceanic climate, for commercial and residential use. The second case study is a building in San Francisco, with Mediterranean climate, for residential use.

Results

CONANALYSIS is structured as a guideline with questions that help to correctly route the research and observations. Site analysis is followed by creating a concept of a Narrative Environment for biodiverse green roofs.



Img. 2: The CoNaNalysis with its different components.

The five steps to follow are:

Site Analysis:
- Step 1: Off-site research
- Step 2: On-site observation of the area
- Step 3: On-sight observation of the roof

Concept creation Narrative environment:
- Step 4: Concept Development: tell stories and find ideas
- Step 5: Concept Formulation

Img. 3: Mind Mapping: Creativity method for the concepts of the Meret Oppenheim green roofs.

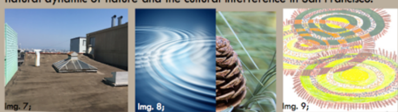
Meret Oppenheim Building in Basel

On the 85-meter-high-rise Meret Oppenheim, located at the in Meret Oppenheim-Strasse in Basel, six roofs between level 1 and level 25 are foreseen for biodiverse green roofs. The building is named after her in her honour. Following the method CoCoNalysis, the author took the idea of honouring her and used Merets Oppenheim paintings "Blume auf Huegel" as inspiration for the Narrative Environment. In the concept design, the two-dimensional painting is transformed into three dimensions by creating hills consisting of local substrate, natural elements from the area (riverbed rocks and tree trunks) and on top seeded with native flowering plants, providing habitat and food source for animals. Each green roof has its own character originated by the choice of different plants and different habitat creation (flower-rich dry meadow and Riverbed). Tenants and office employees can experience local nature with all their senses.

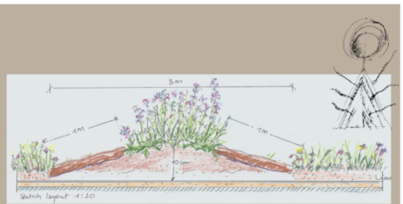
Img. 4; The Meret Oppenheim high-rise in Basel, 5; "Blume auf Huegel", 6; Idea finding process sketch.

Residential Building in San Francisco

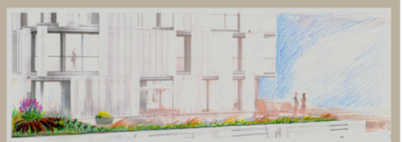
The main goal of the concept 'Interference' is to create a biodiverse green roof that commits to a more biodiverse city. The narrative approach tells a story of the dynamic and interaction of habitats and plant communities with each other, but also refers to the social aspect of interference of people, interacting and moving in the lively neighbourhood in and around Corona Heights in San Francisco. Different circular wave groups of vegetation expand in all directions. In the interference zones, the different plant communities will meet. Analogue to the intersections of waves that are formed by transport of energy, there could be a mixing of plants communities. The Narrative Environment might encourage the audience to reflect about the natural dynamic of nature and the cultural interference in San Francisco.



Img. 7; Residential building in San Francisco, 8; Interference, 9; Design sketch to be applied on the roof



Img. 10: "Blume auf Huegel" implementation at the Meret Oppenheim high-rise in Basel.



Img. 11: "Blume auf Huegel": Visualization at the 15th floor, Meret Oppenheim building in Basel.

Img. 12: Visualization "Interference" at residential building in San Francisco.

Img. 13: Effect of "Interference": Green spaces on the grounds and the roofs connected.

Diskussion and Outlook

The results demonstrate that the combination of a tailored site analysis with the methods of Narrative Environment in CoNaNalysis can be successfully applied in both case studies. The method enabled to identify natural elements and native plants that can be integrated in the design of a Narrative Environment on green roofs that promotes biodiversity.

Yet, due to the inherent limitation of having only two case studies, these results cannot be generalized. Further case studies will be needed to analyze more deeply the potentials of the method and its broader effectiveness.

The author hopes that CoNaNalysis can make a substantial contribution to create more biodiverse green space in densely built cities and promote biodiversity in urban areas. She encourages landscape architects and planners to implement this method for the design of green roofs. Finally, scientific evaluation on its effects can help to further refine the method and extend it to other types of green roofs.

Bachelor Thesis from Lieve Dierckx
Field of Study: Environmental Engineering
ZHAW Institute UNR Waedenswil – October 2018

Reviewer: Dr. Stephan Brenneisen, ZHAW Waedenswil, IUNR
Second reviewer: Monica Ursina Jaeger, ZHAW Waedenswil
Third reviewer: Dr. Chiara Catalano, ZHAW Waedenswil

Sources: Text: **Dakin, K., Benjamin, L. L., & Pantiel, M. (2013).** The professional Guide to green roofs. Portland: Timber Press; **Jaeger, M. U. (2010).** *Manual Module Narrative Environment*, at the Institute of Environment and Natural Resources IUNR, ZHAW Waedenswil. Waedenswil: self-published (undisclosed); **Jaeger, M. U. (2017).** Five Phase of creating a narrative environment. not published; **Mueller, C. (2011).** *Masterthesis: narrative Environment im Kontext von Umwelt und Nachhaltigkeit.* Oberhausen: FernUniversität.
Images: 1 Drawing from Journal Garten und Landschaft 10/2003; **2** by Lieve Dierckx (LD); **3** LD; **4** https://hrs.ch/typo3temp/assets/_processed_/5/e/csm_20160624_Grundsteinlegung_Meret_Oppenheim_2ee9bb0691.jpg; **5** https://kultur.typepad.com/.a/6a00d8341d971853ef017d419edb04970c-pi; **6-7** LD; **8** Ponderosa pine cone https://upload.wikimedia.org/ wikipedia/commons/thumb/e/ed/Pinus_ponderosa_cone_Markl.jpg/1280px-Pinus_ponderosa_cone_Markl.jpg, https://conflictinnovationlab.org/2013/02/19/question-1/; **9 -13** LD;

Task Description

Bachelor-Arbeit		
Studienjahrgang		UI14
Titel		**Konzepte für Design und Gestaltung naturnaher Dachbegrünungen in verschiedenen Natur- und Kulturräumen - Meret Oppenheim Hochhaus Basel, Wohngebäude in San Francisco**
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Aufgabenstellung **Ausgangslage** **Zielsetzungen** **Zusätzliche** **Auftrags-modalitäten**	Ausgangslage Eine der grossen Herausforderungen unserer Zeit ist die Zunahme der Weltbevölkerung. Damit wächst weltweit auch der urbane Raum. Die Verdichtung und Versiegelung nimmt zu. Dadurch gerät der natürliche Wasserkreislauf aus dem Gleichgewicht. Natürliche Böden verschwinden. Als Folge des Klimawandels steigt die Hitzeinsel-Wirkung in Grossstädten, die sich negativ auf die Gesundheit der städtischen Bevölkerung auswirkt. Natürliche Grünräume verschwinden immer mehr und damit auch die Vielfalt der einheimischen Flora und Fauna, die sich dort an die Lebensbedingungen angepasst hat. Als wichtige Massnahme im urbanen Raum, hilft Grün am Gebäude, den Folgen dieser Tendenz entgegenzuwirken. Insbesondere natürliche Gründächer ohne Zusatzbewässerung und inspiriert von natürlich, wertvollen Lebensräumen, können die Natur auf eine nachhaltige Weise wieder in die Stadt bringen. Vor allem, wenn das Substrat und die Vegetation mehrheitlich heimisch sind, kann der Bezug zur natürlichen Umgebung und der Respekt zur Natur wieder hergestellt werden. Naturnahe Lebensräume für einheimische Flora werden geschaffen, wovon auch die einheimische Fauna profitiert. Sie findet ein Ersatzhabitat. Somit kann Biodiversität gefördert werden. Gründächer erbringen weitere nachhaltige Ökosystemleistungen in Städten. Diese Bachelorarbeit befasst sich exemplarisch mit zwei Dachbegrünungskonzepten an zwei Standorten mit unterschiedlichen Klimazonen und in zwei verschiedenen Naturräumen: Das MOH-Gebäude in Basel, Schweiz (Kontinentales Klima) und ein Wohnhaus in San Francisco, Kalifornien, USA (Mediterranes Klima). Gebäudetypologie und Nutzung unterscheidet sich ebenfalls. Es werden zwei Design- und Gestaltungskonzepte für die Planung von natürlichen Gründächern erstellt, wobei der Fokus bei der Gestaltung auf Ökologie und Ästhetik gelegt wird. Die Idee, Kunst und Natur zusammen zu bringen, ist nichts Neues; «Landart» ist dafür ein typisches Beispiel. Auch Städte bieten Hotspots für Kultur und Natur, was sich gut auf den Dächern der Stadt verwirklichen lässt. Das Gründach als Landschaft~~,~~ kann durch die ‚erzählte Geschichte‘ (Narrative Environment) mehr Sinn und einen Mehr-Wert erhalten.

	Die beiden Standorte und ihre Umgebung werden auf ihre Nutzung, Klima, Exposition, Geologie, Substrat und Hydrologie, natürliche Fauna und Flora, sozialen und kulturellen Kontext, sowie Gesetze und Bestimmungen analysiert. Basierend auf früheren Untersuchungen, Literatur-Recherchen, und auf den, im Studium erlernten Kenntnissen, werden standortgerechte Pflanzen, Substrat und Aufbau ausgewählt. So werden bei beiden Konzepten hauptsächlich einheimische Wildpflanzen verwendet, die an den Standort angepasst sind und ein Minimum an Unterhalt und Bewässerung benötigen, was ökologisch sinnvoll ist. Zielsetzung Diese Konzepte sind eine Kombination von Kunst, Design, Naturmanagement und Wissenschaft. Sie bringen – wenn umgesetzt - mehr Biodiversität in die Städte. Daraus können konkrete Projektgestaltungen entstehen. Sie können als Inspiration für zukünftige Begrünungsprojekte wirken. Ebenfalls können sie als Model dienen und in weiteren Städten vorgelegt werden. So können sie dazu beitragen, dass die beiden Städte ihre Ziele von Nachhaltigkeit und mehr natürlichem Grün näherkommen. Kostenplanung und –Berechnungen, sowie Umsetzung der Konzepte, sind nicht Bestandteil dieser Arbeit. Formaler Output Hochladen in Complesis Zusätzliche Auftragsmodalitäten - Bachelorarbeit gemäss Weisungen ZHAW - mündlicher Präsentation - Poster oder Broschüre

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Formale Anforderungen	*Die Weisungen zur Arbeit müssen gelesen und erfüllt werden.* http://www.lsfm.zhaw.ch/science/studium/info/bachelor-studium/wichtige-dokumente.html
Abgabetermin (12.00 Uhr)	*23. August 2018.*
Bemerkungen	in elektronischer Form Die Arbeit wird in Englischer Sprache verfasst.
Arbeitsort	Basel, San Francisco (CA, USA), ZHAW, Wädenswil,

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Titel der Arbeit:	Methodical and design concept for the development of natural green roofs with a Narrative Environment - Applied to the case studies Meret Oppenheim High-rise in Basel and a Residential Building in San Francisco.
Name der/des Studierenden:	Lieve Dierckx
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